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The Douglas Fir Tussock Moth in the Pacific Northwest. A Seminar Sponsored by the United States Environmental Protection Agency, Washington, D. C. November, 1973

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Washington, D.C.

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the Douglas fir tussock moth in the Pacific Northwest

A SEMINAR

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U.S. Environmental Protection Agency

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WASHINGTON, D.C.

Foreword

Henry J. Korp, Seminar Chairman
Deputy Assistant Administrator for Pesticide Programs
U.S. Environmental Protection Agency

OBJECT OF SEMINAR

The object of the seminar "is to bring experts from Federal, State, industrial, academic and environmental agencies and organizations together in a single meeting to explore the technical problems and research needs involved in tussock moth control."

We realize that, due to time limitations, we have not been able to include all persons with experience and expertise in Douglas fir tussock moth research and control on the program, but we have tried to include those directly involved with the current situation. We apologize to those not included on the program and request they participate in the discussion at the end of the formal presentation period.

I would like to point out at this time that this meeting is not designed to discuss the pros and cons of DDT, and it is not a formal hearing for this purpose but, rather, it is a scientific seminar to deal with technical problems and research needs. It is our intention to limit it for this purpose.

We also feel that concerned persons should be informed of the complexities involved in the current program and that this meeting will serve as a briefing session for this purpose.

PHILOSOPHY AND POLICY

It is Administrator Russell E. Train's philosophy that—

> In the development of EPA proposals, it is considered vital that we involve the public in the process to the greatest extent possible. We are not committed to our 1973 decision and any decision to be made in 1974 will be based on a reevaluation of available information relating to the situation as it exists at that time.

EPA INVOLVEMENT IN THE TUSSOCK MOTH PROBLEM

The Environmental Protection Agency has been involved in the tussock moth problem in Washington and Oregon since the summer of 1972, when representatives of the State of Oregon Department of Agriculture asked our Region X office in Seattle for clarification of some of the statements in the EPA Order issued June 14, 1972, canceling most uses of DDT effective December 31, 1972. Since that time, personnel of the EPA Region X office and the Office of Pesticide Programs, Washington, D.C., have maintained close contact with the U.S. Forest Service, Region 6, staff as well as representatives of the State of Oregon Forestry Department and the State of Washington Department of Natural Resources in order to be fully informed on all aspects of the tussock moth situation.

In March of 1973, the U.S. Forest Service and the States of Washington and Oregon made a specific request to be allowed to use DDT under emergency conditions to suppress an infestation of the Douglas fir tussock moth in the States of Washington and Oregon. Subsequently, the city of Walla Walla, Washington, and the Boise Cascade Corporation of Boise, Idaho, made similar requests.

A special investigational team was sent from EPA headquarters to the affected areas to make an on-site appraisal of the present and projected tussock moth damage to the fir stands in southeastern Washington and northeastern Oregon.

In addition to receiving considerable data from the U.S. Forest Service, Region 6, along with their site visits, the EPA team met with members of industry, academic institutions, researchers, environmentalists, Federal, State, and local government agencies, and all other known interested parties.

They found that considerable damage had already occurred in 1972 and, unless the tussock moth was controlled, some additional damage would occur in 1973.

The team found agreement among representatives from the U.S. Forest Service and the States of Oregon and Washington that, due to nuclear polyhedrosis virus, the tussock moth population would probably collapse in 1973 during the third and decline year of its cyclic occurrence. Reports of these on-site investigations were submitted to the Administrator.

After review of the report and due consideration to all factors involved, the Administrator announced that, in his opinion, the benefits did not outweigh the risks of introducing 200,000 pounds of DDT into the environment in the proposed DDT control program. Subsequently, all requests for its use were denied.

We have continued to keep abreast of developments with regard to control of the tussock moth and are aware that, as predicted, additional damage occurred in 1973. We have also been informed that new outbreaks have occurred in 1973 which may need to be controlled in 1974.

In order to obtain up-to-date information concerning the current status and possible 1974 implications of Douglas fir tussock moth activity, representatives of EPA, the U.S. Forest Service, and the States of Oregon and Washington held an open controlled meeting on September 20 at the U.S. Forest Service Region 6 headquarters, Portland, Oregon.

Prior to this meeting, EPA and U.S. Forest Service personnel met with Federal, State, academic, environmental organizations, industrial personnel, and the general public in Walla Walla, Washington, and La Grande, Pendleton, Corvallis, and Salem, Oregon. On-site ground inspection was made between Walla Walla and La Grande and an aerial inspection of the Blue Mountains area was also conducted.

The situation revealed by those meetings is that the nuclear polyhedrosis virus that appears to have been a major mortality factor causing dramatic population collapse in previous tussock moth outbreaks did not develop in epizootic proportions in the Blue Mountains area in 1973, and the dramatic population collapse did not occur.

We have been advised that some 690,000 acres of fir timber type in the States of Oregon and Washington are now infested. This includes about 36,000 acres on the Colville Indian Reservation. An additional 125,000 acres were defoliated in varying degrees in northern Idaho, and a few small areas of 1973 defoliation are reported in southern Idaho, Montana, Nevada, New Mexico, and California. About 197,000 acres were defoliated to some degree in 1972. The U.S. Forest Service projected injury on 449,000 acres in the Blue Mountains in 1973, making the actual infestation approximately 250,000 acres greater than anticipated in Oregon and Washington.

The U.S. Forest Service has indicated that whether direct control of the tussock moth will be needed in 1974 cannot be determined until detailed biological evaluations are made this fall and winter. If the fall egg-mass survey indicates a need for insecticide in 1974, a contingency or emergency use application for DDT will probably be made to EPA around December 15. The U.S. Forest Service's opinion is that DDT is the only pesticide available that will control the tussock moth.

EPA POSITION IF PETITIONED FOR DDT

If petitioners apply to EPA for the use of DDT for Douglas fir tussock moth control, formal hearings to solicit the views of all interested persons will be held in the Northwest as I noted previously. Information obtained at these hearings and derived from other sources will be evaluated in time to reach a decision well in advance of any spring outbreak in 1974.

Contents

Page

Foreword. Henry J. Korp iii

Morning Session:

Douglas Fir Tussock Moth Situation. David A. Graham 3
Control of Douglas Fir Tussock Moth. Bill L. Stevenson 17
State of Knowledge, Work in Progress, and Research Needs for the Douglas Fir Tussock Moth. Robert E. Buckman 21
Oregon's Concerns on the Douglas Fir Tussock Moth Infestation. J. E. Schroeder. 29
Forest Insect Control Through Research. Donald R. Hopkins 33
Technical Problems and Research Needs: What Are They? Carl Stoltenberg 39
Developing Strategic Management Systems for the Douglas Fir Tussock Moth. Alan Berryman 45
Status of Knowledge on the Douglas Fir Tussock Moth. Ronald W. Stark 51

Afternoon Session:

The Technical Problems and Research Needs: What Are They to the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior? Richard E. Pillmore 57
Douglas Fir Tussock Moth Research Needs: A Position Paper. Steven G. Herman. 61
Preventing Douglas Fir Tussock Moth Outbreaks: A View From the Pesticide Industry. R. P. Harrison 65
The Technical Problems and Research Needs: What Are They to Industry? Philip A. Grau 71
Tussock Moth Virus Production. Edward B. Westall 75
Forest Industry's Views Regarding Tussock Moth. William H. Lawrence 79

Appendixes 83

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Morning Session

DOUGLAS FIR TUSSOCK MOTH SITUATION

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INTRODUCTION

MR. KORP: Good morning, ladies and gentlemen. My name is Henry Korp. I am the Deputy Assistant Administrator for Pesticide Programs in Washington. We are going to try and stay on schedule here today, and that is the reason for my prompt start. First in the order of things is a welcoming address from Mr. James A. Agee, who is Regional Administrator for the Agency in Region X in Seattle.

MR. AGEE: Henry, thank you very much. I am here to welcome you this morning. This seminar is very important to our Agency. I am sure it is very important to you and that is why you are here. I would like to thank all of you for coming. We are really looking for your input—all of you from the private sector, from the academic sector, from the regulatory agencies, State and Federal. For a good seminar, we need your data.

I think many Federal agencies today have an innate capability to make mistakes. I am not saying we have made a bad judgment with the tussock moth, but the subject is up for reassessment. Mr. Train announced a day or two ago that we will hold some formal public hearings starting the week of January 14 in three of our Northwest cities—Boise, Portland, and Seattle. We also have a hearing in Washington, D.C., that week to consider a formal request for the use of DDT for the control of tussock moths in the Northwest. I want to bring that message to you, and again I want to welcome you and thank you for your participation.

MR. KORP: Thank you, Jim. I am going right ahead to our first speaker on the program. This is Dave Graham, Branch Chief for Insect and Disease Control Group, United States Forest Service, Region 6, in Portland, Oregon.

MR. GRAHAM: Good morning, it is nice to be first. I hung up two maps back in the back of the room, I think everybody has probably looked at them by now. They are more or less broad-brush-type maps, but they depict the area we are talking about. They will be available throughout the day. In regard to my presentation, I have a few extra copies. If you would be interested in having one, see me sometime during the day.

Some of the material that I will present will repeat what Mr. Korp has just covered. But it is important to indicate—in the proceedings—that this information comes from the Forest Service. Therefore, I think it is well to cover some of it, particularly in regard to

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acreage figures. Acreage figures necessarily have to change, particularly those relating to an insect outbreak. I think almost everyone here can realize the difficulty of precisely determining acres involved in that vast area covered by the maps. It is a difficult and complex job, and as we begin to refine information—acreage information on the basis of our surveys—the acreage figures will change.

PRESENTATION

Introduction

The Douglas fir tussock moth is usually endemic in western forests and most years not in evidence at all. However, serious outbreaks have occurred several times in the past, notably 1947, 1956, and 1965. This current Pacific Northwest outbreak first developed in central Washington and the Okanogan Valley in 1971. Some 2,400 acres were affected but only about 250 acres seriously damaged. One of the most obvious heavily damaged areas was located near the main highway just west of Cashmere.

The outbreak literally exploded during 1972. About 197,000 acres in the States of Oregon and Washington were defoliated to some degree. A total of about 15,000 acres were heavily damaged. Most of the defoliation and damage occurred in the La Grande, Oregon, and Walla Walla, Washington, areas.

Hosts—Life Cycle

Douglas fir, white fir, and grand fir are the preferred hosts for the Douglas fir tussock moth. However, the caterpillars (larvae) will feed on many other trees and shrubs after the preferred foliage has been eaten. In some of our current outbreak areas, considerable damage to ponderosa pine, subalpine fir, and spruce has occurred. The newly hatched larvae feed on the new needles in the spring. Older needles are consumed as the larvae mature and increase in size. Infected trees begin to turn red from the top down in June. By mid-July, entire trees are often defoliated and killed in the same year, or by subsequent bark beetle attack because of the weakened condition in following years. Sometimes only tops of trees are seriously defoliated. Most of these eventually recover, although dead tops may develop.

Tussock moth eggs hatch between mid-May and early June. Newly hatched larvae are about one-eighth inch long and covered with long hairs. This hair and light weight allows them to be carried by the wind for quite long distances. However, this air transport does not result in significant damage very far from the point of origin. Full-grown larvae are about 1¼ inches long. They have two long, dark tufts of hair just back of the head and a similar single tuft on the other end. Four dense, buff-colored tussocks of hair grow along the middle of the back. Larvae feed through July and early August until they enter the cocoon or "resting" stage. This period lasts from 10 to 18 days depending on temperature when the moths emerge. The female moth is wingless and lays her eggs on the cocoon right after she emerges and mates with the winged male. Each female lays 150-250 eggs.

Biological Evaluation

A very thorough evaluation of the current Oregon-Washington situation was made by Forest Service and State forest entomologists during 1972 and early 1973. This indicated that the population was likely to increase within the areas partially defoliated in 1972 and cause considerable damage in 1973. This evaluation also showed that there would be about 449,000 acres defoliated in 1973 and a considerable increase in the area seriously damaged by the tussock moth.

Environmental Statement

Because of the large area affected and the possible need to apply chemicals over large forest areas, an environmental statement in accordance with the 1969 National Environmental Policy Act was prepared by the Forest Service (Region 6) with assistance from the two States and the Northwest Forest Pest Action Council. This was filed in final form with the Council on Environmental Quality on April 26, 1973.

During the preparation of the Environmental Statement it was determined that it might be necessary to use DDT in 1973 to control the outbreak. No other chemical suitable for large-scale forest-land aerial application has been proven effective against the tussock moth. DDT was no longer registered for use. Therefore, an emergency-use application for DDT on an "if needed" basis was made to the Federal Environmental Protection Agency (EPA). Public response to the Environmental Statement was tremendous. Over 2,000 letters, statements, and signatures were received, mostly from the affected areas. Over 95 percent were in favor of using DDT if it was necessary in order to prevent excessive tree loss during 1973.

Control Tests

Four insecticides, Zectran, Dylox, Sevin 4 Oil, and Bioethanomethrin, and two biological agents, Dipel (*Bacillus thuringiensis*) and the natural occurring tussock moth virus, were extensively field tested during 1973. Because requests for the emergency use of DDT in 1973 were denied by the Federal Environmental Protection Agency on April 20, 1973, the Zectran test was expanded considerably, mostly on private lands in Oregon and the Walla Walla watershed. This chemical had shown at least some promise in early tests and no other alternatives were available. It was also recommended by the EPA as a suitable substitute for DDT. About 70,000 acres were treated at a total cost of $7.50 per acre during June and early July 1973 in Oregon and Washington with a double application of Zectran (0.15 pound in 1 gallon of fuel oil per acre each application). Private landowners paid one-half of the cost on their lands that were treated.

A preliminary evaluation of these tests has been completed. Large numbers of insects were killed on most of the plots, but none of the chemical treatments saved enough foliage or trees to be able to consider them effective enough for operational use. The insect population left after treatment apparently was too high, and observations made so far indicate that unacceptable damage occurred in most of the treated areas. The two other materials, the natural virus and *Bacillus thuringiensis*, appear quite promising and will be pilot tested on a large-scale basis during 1974. Both of these materials have only been tested on a small-scale basis so far. Further, the natural virus cannot be synthesized and is not available in large quantities. The *Bacillus thuringiensis* formulation used is not available commercially. Therefore, none of these materials can be recommended for registration and/or operational use in 1974.

Current Outbreak

The outbreak continued as expected during 1973 in most areas. However, a number of additional areas became defoliated that were not predicted. Also, in some areas where we anticipated only light damage, very serious damage occurred. Some 690,000 acres of fir timber type in the States of Oregon and Washington are now defoliated. This includes about 36,000 acres on the Colville Indian Reservation.

An additional 122,000 acres in northern Idaho and about 10,000 acres in southern Idaho are reported to have been defoliated during 1973. A few small areas of 1973 defoliation are also reported in Montana, Nevada, New Mexico, and California. None of these small areas are considered very serious or threatening except to scattered recreation, shade, and ornamental trees.

The following tables present this information in more detail. Tables 1 and 2 (from the 1973 Final Environmental Statement) are the projections that were made based on all of the biological data available at that time. Tables 3 and 4 reflect the actual situation at the end of the 1973 season. The 355,000 acres shown as acres dead plus class I plus class II on tables 3 and 4 are comparable to the approximately 281,000 acres indicated in table 2. Insect populations were higher than anticipated, and so caused more severe damage than expected, especially in areas partially defoliated in 1972.

Surveys to determine the amount of heavy damage and actual timber loss due to the 1973 insect population are currently underway. As soon as this is completed, salvage timber sales and plans for reforestation will be finalized. Most of the accessible timber killed by the tussock moth during 1972 has been salvage logged, both on private and on national forest land.

Table 5 gives additional estimated volume information. The figures reflect only the loss in merchantable-size (12 inches or more diameter at breast height) trees. No estimates have been made for the young growth tree loss.

Forest Fire Impact

Tussock-moth-damaged trees are very flammable and create a very serious fire hazard. Tree needles killed by the tussock moth are very dry and literally explode when exposed to fire. In anticipation of this, extra helicopters, retardant planes, and crews were stationed this year in or near the outbreak areas. Two large fires that involved tussock-moth-killed trees have occurred so far during 1973—one at Perry, near La Grande, Oregon, which was controlled at 6,100 acres, and one called the Freezeout Fire east of Joseph, Oregon, which was controlled at about 16,000 acres. About 200 acres of tussock-moth-damaged area was burned in the La Grande fire, and about 3,000 acres in the Freezeout Fire. Just how much the tussock moth contributed to the size of these fires and control difficulties is not precisely known, but there is no question that it was a very significant factor. The exceptional 1973 summer drought condition also contributed significantly to the fire hazard.

Predictions for 1974—Survey Methods Used

A natural virus disease and a number of insect parasites usually cause tussock moth outbreaks to eventually collapse. The virus disease did increase substantially during 1973,

Table 1.—Acres of defoliation, by ownership, projected for 1973

Area	Acres of defoliation
Oregon:	
Blue Mountain unit:	
Umatilla National Forest	130,340
Wallowa-Whitman National Forest	55,810
State and private	119,680
Subtotal	305,830
Washington:	
Blue Mountain unit:	
Umatilla National Forest	93,770
State and private	11,710
Subtotal	105,480
Blue Mountain total	411,310
Wenatchee unit:	
Wenatchee National Forest	2,440
Private land	2,560
Subtotal	5,000
Okanogan unit:	
Okanogan National Forest	280
Private land	10,720
Subtotal	11,000
Colville unit:	
Colville Indian Reservation	12,400
Private land	9,840
Subtotal	22,240
Grand total	449,550

Note.—Total projected areas of defoliation based on results of ground and aerial surveys. Includes all areas which are projected to have visible defoliation during 1973. Includes all of areas defoliated to some degree in 1972.

Table 2.—Projected acres of substantial defoliation and tree loss, by ownership

Area	Acres
Oregon:	
Blue Mountain unit:	
Umatilla National Forest	121,890
Wallowa-Whitman National Forest	11,560
State and private	66,650
Subtotal	200,100
Washington:	
Blue Mountain unit:	
Umatilla National Forest	54,400
State and private	7,000
Subtotal	61,400
Blue Mountain total	261,500
Wenatchee unit:	
Wenatchee National Forest	2,440
Private land	2,560
Subtotal	5,000
National forest subtotal	190,290
State and private subtotal	76,210
Grand total	266,500

Note.—Total areas of infestation based on results of ground and aerial surveys. These figures include the 15,660 acres with substantial tree mortality that resulted from 1972 defoliation. Approximately 14,500 additional acres of national forest lands that will be used for insecticide tests and experimental purposes are not included. Much of the anticipated tree loss will result from subsequent bark beetle attacks following the loss of tree vigor caused by the tussock moth.

Table 3.—Douglas fir tussock moth defoliation acres, by ownership and damage class: Oregon and Washington, 1973

Area	Acres dead[1]	Acres of defoliation by damage class			Total
		Class I[2]	Class II[3]	Class III[4]	
Oregon:					
National forest	9,350	27,110	121,070	139,860	297,390
Indian lands			30	30	60
State and private[5]	5,530	15,410	51,020	69,040	141,000
Subtotal	14,880	42,520	172,120	208,930	438,450
Washington:					
National forest	2,310	9,570	78,340	76,630	166,850
Indian lands		2,810	12,200	21,160	36,170
State and private[5]	80	7,170	13,000	28,040	48,290
Subtotal	2,390	19,550	103,540	125,830	251,310
Total:					
National forest	11,660	36,680	199,410	216,490	464,240
Indian lands		2,810	12,230	21,190	36,230
State and private[5]	5,610	22,580	64,020	97,080	189,290
Regional total	17,270	62,070	275,660	334,760	689,760

[1] Areas of heavy mortality from defoliation in 1973. Includes areas that have been salvage logged.

[2] Fifty percent or more of the host type has been completely defoliated.

[3] Fifty percent or more of the host type has at least the top quarter of the crown completely defoliated.

[4] Host type has defoliation visible from survey aircraft. The current year's foliage has been removed on most trees but less than a quarter of the crown has been completely defoliated.

[5] Includes Bureau of Land Management acres.

but not early enough to prevent serious damage. Evidence of the disease can now be found in most of the outbreak areas, which may indicate that insect populations may be quite low, at least in some areas, in 1974. The actual significance of this will be determined next March from larvae hatched in the laboratory from egg masses collected this fall.

Some of the areas defoliated for the first time in 1973, which are separated from the 1972 outbreak area by considerable distances, may be new outbreaks without much disease or parasitism. If this conjecture is true, these areas have potential for being seriously damaged in 1974 if not controlled.

Our fall 1973 egg-mass survey and examination will permit determination of this prior to the need for any control action. The survey has been completed except for some possible additional data collection on private land.

Table 4.—Acres of defoliation, by ownership and damage class, in 1973
[Includes areas affected during 1972]

Area	Acres dead[1]	Acres of defoliation by damage class			Total
		Class I[2]	Class II[3]	Class III[4]	
Oregon:					
Blue Mountain unit:					
Umatilla National Forest	9,180	17,340	86,150	74,970	187,640
Wallowa-Whitman National Forest	170	9,770	34,920	64,890	109,750
BLM (Lockout Mountain)		50	1,350	170	1,570
Umatilla Indian Reservation			30	30	60
State and private	5,530	15,360	49,670	68,870	139,430
Oregon subtotal	14,880	42,520	172,120	208,930	438,450
Washington:					
Blue Mountain unit:					
Umatilla National Forest	2,310	9,250	78,300	76,350	166,210
State and private	80	850	10,770	13,140	24,840
Subtotal	2,390	10,100	89,070	89,490	191,050
Wenatchee unit:					
Wenatchee National Forest		320	40	120	480
State and private		840	200	200	1,240
Subtotal		1,160	240	320	1,720
Okanogan unit: State and private		2,080	750	1,020	3,850
Subtotal		2,080	750	1,020	3,850
Colville unit:					
Colville National Forest				160	160
Colville Indian Reservation		2,810	12,200	21,160	36,170
State and private		2,560	1,080	11,680	15,320
Subtotal		5,370	13,280	33,000	51,650
N.E. Washington unit: State and private		840	200	2,000	3,040
Subtotal		840	200	2,000	3,040
Washington subtotal	2,390	19,550	103,540	125,830	251,310
Grand total	17,270	62,070	275,660	334,760	689,760

[1] Areas of heavy mortality from defoliation in 1973. Includes areas that have been salvage logged.

[2] Fifty percent or more of the host type has been completely defoliated.

[3] Fifty percent or more of the host type has at least the top quarter of the crown completely defoliated.

[4] Host type has defoliation visible from survey aircraft. The current year's foliage has been removed on most trees but less than a quarter of the crown has been completely defoliated.

Table 5.—Merchantable volume losses
[In thousands of board feet]

Year	Salvaged or to be salvaged		Not salvaged	
	National forest	State and private	National forest	State and private
1971	400	200	0	0
1972	49,000	50,000	50,000	5,000
1973	324,000	186,000	170,000	20,000

Note.—The volumes "not salvaged" will deteriorate prior to the ability to gain access to the affected stands. Some of this volume is scattered trees which would be uneconomical to salvage by themselves. Adding green timber to the market at this time in order to salvage them is impractical.

Survey Procedure. Upon completion of egg laying by the tussock moth in late September, a survey was started in defoliated (as determined by aerial survey) and adjacent areas to collect data to aid in preparation of a report on the trend of the outbreak for 1974. This survey will provide data on the most important but not all of the factors that must be considered and evaluated before a final decision can be made on the need for control in specific areas.

Data collected will indicate the capability of the current moth population in the egg stage to continue or intensify the infestation. Prior to egg hatch in the spring of 1974, observations will be required to insure that abnormal numbers of egg parasites or adverse weather conditions during the winter have not significantly reduced the viability of the eggs.

Objectives. It is the objective of this survey to gather data on several factors which, when combined with known information and the results of investigations currently underway, will aid to—

1. Delineate areas previously defoliated which contain the moth population in a density capable of continuing this defoliation.
2. Delineate areas outside areas previously defoliated containing egg masses capable of producing tussock moth populations which could cause unacceptable defoliation in 1974.
3. Estimate the
   - a. Number of new egg masses
   - b. Ratio of old to new egg masses
   - c. Number of old egg masses
   - d. Incidence of virus present in overwintering eggs

4. Although not a primary objective, a determination as to whether there is a correlation between the measurements on the population density plots and the relative time plots will be made in order to possibly improve future surveys.

The survey will also include--

1. Recording observations on host type and condition

2. Collecting eggs for determining the incidence of virus

Sampling Unit and Plot Density. The sampling unit consists of 10 trees in the approximate center of each section of a township. Theoretically, this unit will be 640 acres in size and there will be 36 units in a township. It is realized that sections are not uniform, but sufficiently uniform to justify the assumption that we have a systematic sample of the area infested.

Sampling design will permit poststratification with double sampling. An attempt will be made to establish one moth-population-intensity measure plot and five relative-population time plots in each section. When possible, within manpower and travel limitations, all sections mapped during the aerial survey as showing some degree of defoliation will be surveyed. In addition, in areas where there is host type, a belt three sections wide surrounding the infestation will be surveyed.

If data collected within the belt indicate that it is infested, then the belt will be broadened until a belt of uninfested host type one section wide has been surveyed on the perimeter of the defoliated area.

Selection of Plot Locations. Upon arrival at the section to be surveyed, the crew drives the road system and selects the spot where the road comes closest to the center of the section. A branch on a tree at the edge of the road is tagged. After pacing in 1 chain at right angle to the road, the first host-type tree is selected as the first sample tree on the plot.

At this location, both a population-intensity measure plot and a relative-population time plot are established. In addition, in each section four more relative-population time plots are established at 0.2-mile intervals on the road in either direction from the intensity plot without leaving the section.

In cases where host trees are not present at these locations, the plots are centered in the first host-type stand encountered as one travels forward along the selected road.

In cases where there are no roads within the section, the double plot is located on a trail as close to the section center as the trail and host-type trees permit. The remaining four relative-population time plots are then spaced at 8-chain intervals along the trail.

Population-Density Measure Plot Procedure. The following procedure, using a two-man crew, is used:

1. With a felt-tip pen, mark a 3-foot section of white ribbon with the section number, date, and initials of the crew members.

2. Secure the ribbon to a branch tip on the edge of the road where it can readily be seen from a passing vehicle.

3. Pace off 1 chain (66 feet) at right angle from the road edge.

4. Select for the first tree to be sampled the nearest host-type tree with foliage that can be reached with the pruning saw.

5. Saw off one entire branch from the midcrown of the tree.

6. If there is no foliage on the midcrown branches, then lower the saw and cut the highest branch with foliage.

7. If you cannot reach the midcrown with the saw, cut off the highest branch you can reach.

8. Measure from the branch tip along the branch stem to where the foliage stops. Record to the closest inch.

9. Measure the width of the foliage at the widest location. Record to the closest inch.

10. Count the old egg masses on the foliage. Record.

11. Count the new egg masses on the foliage. Record.

12. Repeat the procedure on the next nearest nine host trees that meet the specifications for available foliage and size.

Relative-Population Time Plot Procedure. The following procedure is used to collect the data from five time plots in each section:

1. The center of the first time plot is the fifth tree of the population intensity plot.

2. The area to be examined is limited to a 118-foot radius of this tree.

3. Using a timer (darkroom, cooking, watch, etc.) one man searches for 10 minutes or two men for 5 minutes.

4. Host and nonhost trees, foliage, trunks, undergrowth, stumps, rocks, etc., are examined for egg masses. The only limitation is that the observer must be able to get close enough to determine if the egg mass is an old one or a new one.

5. Two counts are kept on tally records; one of old masses observed and the second of new egg masses observed.

Virus Incidence Survey. As an aid in determining the incidence of virus in the outbreak, five new egg masses are collected in each section where eggs are found on the intensity plot. One egg mass will be collected from each of the first five branches containing eggs. If five of the ten branches surveyed do not contain eggs, then five masses are collected evenly from those that do. If less than five egg masses are found, the remainder is collected from the time plots. The number collected is recorded.

Egg masses collected are placed in a small paper bag that has been labeled with the township, range, and section of the collection plot. The bags are stored in a cool, foam box until deposited at survey headquarters.

Rearing of eggs to determine the virus incidence will be done in the laboratory during February and March 1974. Egg viability will also be determined at this time.

Treatment Criteria

Treatment criteria that will be used in planning control strategy for 1974 have been developed as follows:

The following evaluation key will be used in a stepwise fashion as the sequence of specific biological data becomes available. Each plot (section) that has been surveyed will be subjected to this analysis. If the minimum criteria are exceeded, the section will be rated "+" to indicate that control is recommended. After these are plotted on a map along with the sections that do not meet the criteria (rated "-"), a recommended treatment zone will be drawn in. The minimum figures shown were developed from mixed (true fir, Douglas fir) stand data. Pure Douglas fir stands that meet the minimum criteria at any one of the decision points can be considered a somewhat higher risk. Host-type information and the judgment of the entomologist in charge will also be used in plotting the final treatment boundary. These criteria are considered to be thresholds above which unacceptable foliage loss and top kill will occur if the area is not treated.

An emergency request for the use of DDT, contingent on the development of the subsequent biological factors shown, will be made at step 4 *or* step 8 if the data indicate the risk of loss is high at that point.

1. No new egg masses—no further control consideration.
1a. Some new egg masses—some risk (2).

    2. For areas that are in defoliation class I and II.

        3. Egg-mass ratio less than 1 old to 0.01 new[1]—low risk.
        3a. Egg-mass ratio equal to or more than 1 old to 0.01 new[1]—high risk dependent on step 4.

        4. Egg-mass density less than 0.1—low risk.
        4a. Egg-mass density equal to or more than 0.1—high risk dependent on step 5.

        5. Virus level equal to or more than 50 percent—low risk.
        5a. Virus level less than 50 percent—high risk dependent on step 6.

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[1] From egg-mass-intensity *or* time-plot data.

6. Viable egg density less than 20 per 1,000 square inches of foliage—low risk.
6a. Viable egg density equal to or more than 20 per 1,000 square inches of foliage—high risk dependent on spring egg viability verification.

2a. For areas that are in defoliation class 3 and 4.

7. Egg-mass ratio less than 1 old to 0.1 new[1]—low risk.
7a. Egg-mass ratio equal to or more than 1 old to 0.1 new[1]—high risk dependent on step 8.

8. Egg-mass density less than 0.1—low risk.
8a. Egg-mass density equal to or more than 0.1—high risk dependent on step 9.

9. Virus level equal to or more than 30 percent—low risk.
9a. Virus level less than 30 percent—high risk dependent on step 10.

10. Viable egg density less than 20 per 1,000 square inches of foliage—low risk.
10a. Viable egg density equal to or more than 20 per 1,000 square inches of foliage—high risk dependent on spring egg viability verification.

What Is Being Done

It is too late this year for any type of chemical control. The insects have now completed their feeding for this year and are in the egg stage. All damage that will occur in 1973 has been done. The eggs will not hatch until late in May or early June next year. These insects can only be controlled with chemicals soon after they hatch and while they are in the caterpillar (larvae) stage. To be effective, chemical controls must be used during June or early July.

Because of the very complex nature of the problem and the need to bring all of the best expertise available in on the development of solutions, an Interagency Steering Committee—composed of key members from the Washington State Department of Natural Resources, Oregon State Department of Forestry, Idaho State Department of Lands, Forest Service (both administration and research), Bureau of Indian Affairs, Bureau of Land Management, Oregon State University, and the Federal Environmental Protection Agency—was formed early this year.

The "doing jobs" will be accomplished by a technical working group composed of members from the Federal and State agencies who have direct responsibility (by law) for forest insect detection and control (Washington State Department of Natural Resources, Oregon State Department of Forestry, Idaho State Department of Lands, and the Forest Service). This working group will coordinate all policy actions with the Forest Pest Action Councils and other concerned units and groups as needed.

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[1] From egg-mass-intensity *or* time-plot data.

This Steering Committee has developed a four-point action plan as follows:

1. *Accelerate through research and development the search for alternatives to persistent pesticides.* Field experiments in 1973 indicate that the two microbial sprays (virus and *Bacillus thuringiensis*) were effective in reducing tussock moth populations. The next steps are to refine formulations of these materials and to evaluate their effectiveness and safety when applied on a larger scale operational basis to several thousand acres in 1974. Promising chemicals, particularly Dylox and Sevin 4 Oil, should also be further evaluated in a series of small-scale tests. When the present outbreak subsides, it may be several years before another arises. Accordingly, an all-out effort should be made in 1974 to develop acceptable control measures for future use.

2. *Seek contingency approval for use of DDT.* Whether direct control of the tussock moth will be needed in 1974 cannot be determined until detailed biological evaluations of the populations are made this fall and winter. If the fall egg-mass survey indicates that there may be a need for direct chemical control in 1974, a contingency or emergency-use application for DDT will be made to the Environmental Protection Agency about December 15, 1973. DDT will not be used unless the lack of virus and parasites indicates that it will be necessary. In addition, provisions of the National Environmental Policy Act will be followed.

3. *Improve systems for detecting the presence and numbers of the tussock moth.* Work has been accelerated on methods for surveying and sampling tussock moth populations by government agencies and private organizations. For example, a study is in progress to identify and synthesize the sex attractant of the female moth. Availability of the tussock moth attractant would provide a quick, efficient survey tool for early detection of outbreaks.

4. *Continue the Interagency Tussock Moth Steering Committee as the coordinating body for handling policies and issues.* The tussock moth poses many complex problems such as resource and environmental impacts, intermingled land ownership, and control decisions. Action programs require careful review of a broad array of biological, environmental, and economic facts. The Steering Committee, comprised of Federal and State agency representatives, will provide the necessary coordination with the Western Forest Pest Action Councils and other concerned groups and individuals prior to decisionmaking.

DISCUSSION

MR. KORP: Thank you, Dave. Now we are about on schedule. If there are questions, specific to the content of Dave's remarks—

WILLIAM HAZELTINE: I thought I understood you to say that EPA—in connection with their denial on April 20—recommended the use of Zectran. I wonder if you would clarify that, please?

MR. GRAHAM: Would you repeat the question, please?

MR. HAZELTINE: I thought that you stated that EPA had recommended the use of Zectran and I wanted to know if you meant to say the word "recommend."

MR. GRAHAM: Maybe I should get a direct quote from the letter of denial that was written to Assistant Secretary Long. I have a copy with me; I am sure other members have also. Possibly the word was "suggest." But it was very definitely pointed out, in that denial of the request to use DDT, that we should seriously consider using Zectran as a possible substitute.

JOHN THOMPSON: Dave, you mentioned that the Steering Committee had a four-point program. I only got three—research for new chemicals, application for the use of DDT, and improved protection and evaluation. Is there a fourth?

MR. GRAHAM: Yes, the fourth is self-perpetuation. The fourth point was that the Steering Committee was working well and it was consensus of the group that this method provides a better united front on the subject. Now I want to make clear that this committee is temporary, with a self-destruct device. It has been formed for the tussock moth emergency situation only. These outbreaks are cyclic. It is hoped that the cycle will be over before too long and the Steering Committee will disband.

A VOICE: Dave, what does the committee feel will be the number one research need?

MR. GRAHAM: Research needs have not yet been specifically identified by the Steering Committee. I would defer that question—possibly to Dr. Buckman who will be on the program.

CONTROL OF DOUGLAS FIR TUSSOCK MOTH

Bill L. Stevenson, Ph. D.
Assistant Director, Forest Pest Control
U.S. Forest Service, Washington, D.C.

INTRODUCTION

MR. KORP: We have two other speakers from the Forest Service. For control, our next speaker is Dr. Bill Stevenson, Assistant Director, Forest Pest Control, Forest Environmental Protection, Environmental Quality Evaluation, U.S. Forest Service, Washington, D.C.

MR. STEVENSON: Thank you, Mr. Korp. It is indeed a pleasure to have the opportunity to participate with this group in the Northwest. I have enjoyed both professional and nonprofessional working relationships with members of the Forest Service, Environmental Protection Agency, university, and industry, so I really feel at home.

Two questions came to my mind this morning, and I would like to begin with them. One is, What sort of problems are we going to face in all areas of pesticide application with the energy crisis for carriers. I do not have the answer, I am just supplying the question. Another thing—Mr. Korp, I am sure that you have investigated this—the National Center for Toxicological Research in Pine Bluff has excellent facilities and I think might be able to give us some assistance when it comes to microbials. Possibly that group has some ideas and equipment to supply microbials if we reach a place where we need them.

PRESENTATION

The President's Science Advisory Committee, in its report entitled "Use of Pesticides," acknowledged the benefits of pesticides, but recognized the need to evaluate the risks to man and his environment associated with their use. This is certainly a broad assessment, but one which the Environmental Protection Agency and the U.S. Forest Service must consider in great detail. A coordinated program of evaluation, instruction, and technical assistance encompassing the affected areas in Washington, Oregon, and Idaho can best be implemented through joint efforts by these two agencies.

The Forest Service, in keeping with U.S. Department of Agriculture policy on pest control, will practice and encourage the use of those means of practicable, effective pest control which result in optimum protection against pests and the least potential hazard to man, his animals, wildlife, and the other components of the natural environment. Integrated control systems utilizing both chemical and nonchemical techniques are used and recommended.

The implementation of integrated pest-control systems are providing satisfactory results in some instances. We recognize the importance of controlling pests of forest and agricultural commodities generally. We have responsibilities to provide the technology to control such pests, to take action to control them on Federal lands under our jurisdiction, and to cooperate with the States in control efforts on non-Federal lands.

In all instances of pesticide use, there should be a careful balancing of benefits and risk in such a way as to best serve the interest of society as a whole. Such evaluations are especially essential whenever consideration is given to the use of persistent pesticides such as DDT, which have been proven effective and are needed for emergency use, on a case-by-case basis until better methods are developed. Some groups consider the present tussock moth outbreak an environmental disaster and a very serious economic impact on the forest resource. If final biological evaluations and an analysis of all available alternatives indicate that direct control is necessary, it would seem irresponsible for forest managers and public agencies to not take all feasible actions, on an emergency basis, to control the epidemic.

Effective methods of control for several important forest insects are not known at this time, and serious epidemics can develop quickly with very little warning. In keeping with this concern, if proven persistent pesticides are essential to combat these pests, they should be used in minimal effective amounts and applied only to the infested area at minimal effective frequencies. This can be achieved as demonstrated recently when permission for emergency use of DDT was granted by the Environmental Protection Agency for control of the pea leaf weevil.

In the tussock moth situation the assessment of the Department of Agriculture and the Environmental Protection Agency was that control factors such as natural virus and parasites would cause a collapse of the infestation. It was reasonable to believe on the basis of past experience that the population collapse would occur. Studies are underway to determine the present trend of the infestation and to quantitatively forecast damage. If the forecast predicts continuing substantial damage, we will again petition the Environmental Protection Agency for the use of DDT.

Procedures for authorizing the general, restricted, and emergency use of DDT or any other pesticide are presently set forth in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended by the Act of October 21, 1972 (16 U.S.C. 136 et seq.). Section 18 of the amendments vest the Administrator of the Environmental Protection Agency with discretionary authority to exempt any Federal or State agency from any provisions of the Act if he determines that emergency conditions exist which require such exemption.

Legislation modifying the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the use of DDT in controlling insect infestations on forest or agricultural lands, would establish a precedent for similar legislation involving other pesticides and uses. The result would be an erosion of the authority and purposes of FIFRA as amended in October 1972. Additionally, this kind of an exception would create public confusion about the purposes and meaning of FIFRA regulations and other pesticide controls.

The tide is changing; scientists, entomologists, and principal users of pesticides will need to adapt to new techniques in pest control. In order to take this step forward, we need to accelerate and support cooperative research with public and private organizations and industry in the development of pest-control materials and methods. Increased Federal control is evident, especially over pesticides with long residues. Alternative pesticides, such as the organophosphates, that break down more rapidly, will likewise need to be applied more frequently, and in turn often raise the cost per acre for treatment.

Pesticide treatment has been and can be expected to continue to be a major technique in pest control, but the greatest opportunities for pest control in the future lie in developing more integrated control systems.

Summary

If the fall egg-mass survey indicates there may be a need for an insecticide in 1974, an emergency-use request for DDT will be made to the EPA by mid-December.

Precise criteria based on insect population levels, stand condition, and incidence of natural control agents will be established to determine the need for emergency use of DDT.

Direct control methods will not be used unless the lack of virus and parasites indicates that it will be necessary.

If an emergency request is deemed necessary and submitted, officials will continue to monitor the egg masses in laboratory conditions throughout the winter.

If there is a substantial destruction of the moths from virus, the request for DDT could be called off because it would mean the natural collapse of the infestation is ready to happen.

Ultimately, we know it will happen (1974-75).

Research is being conducted to try and develop effective alternatives to long-lasting pesticides such as DDT.

When the present outbreak subsides, it may be several years before another rises. Accordingly, an all-out effort should be made to develop acceptable control measures for future use.

DISCUSSION

MR. KORP: Thank you, Bill. Is there anything specific to Bill's—? John Thompson?

MR. THOMPSON: A point of clarification. Did I understand you to say that the Department of Agriculture and EPA felt that there would be a collapse?

MR. STEVENSON: That is my understanding. Is that correct, Mr. Korp? May I refer this question to Mr. Korp?

MR. THOMPSON: If you were in agreement with the collapse, why was the application made for DDT?

MR. STEVENSON: Well, I am a neophyte in the Department of Agriculture, so I really could not comment officially. Dave, you may be able to help.

MR. GRAHAM: Certainly. This is a very important and critical point. The population, as I mentioned, collapsed in a good part of the outbreak area. But it is the timing of the collapse that is important. When is the population going to collapse? Before or after serious damage occurs? The predictions were that, at the end of the 1973 growing season and caterpillar stage of the insect, the population (at least in those older outbreak areas) would collapse. We think it has done that. Of course, during that collapse stage we suffered a tremendous amount of damage in some, not all, of the areas.

MR. BERRYMAN: Perhaps the question should be why the population didn't collapse in the areas where collapse was expected. What reasons are there for failure to collapse?

MR. GRAHAM: Certainly that is a very important question, too, and it is part of the additional looking that we are doing. Can everyone hear the questions? This question was in regard to the population collapse and whether it may be more important to look at why the population did not collapse in some of the areas as predicted. Now, of course, there are a number of variables involved. We are fairly certain that the population (as of this point, we have not summarized all our data) has collapsed in the areas where the population has been in existence for 3 years. There probably are some exceptions, but I think our 1973 fall egg-mass survey will show that the population has collapsed in a good part of that area. Now let me be sure that I do not indicate that all of this area is in the same phase. We have evidence that some of the collapse started in 1972 and some in 1973. And of course—I am talking about the Blue Mountains now—we must have had a population in 1971.

VERNON MARLL, Columbia County Commissioner (Dayton, Washington): I would like to ask Mr. Graham a question. In these areas where we have seen such a high population of tussock moth (and we are in the heart of this thing in Columbia County), is there a possibility that in place of a collapse part of this decline is actually from starvation? Isn't it a matter of starvation as well as the virus?

MR. GRAHAM: The essential part of the question is whether the population has collapsed in those areas in its entirety and, if it has collapsed, did it collapse because of starvation in some areas. To answer the latter part of the question, yes, apparently the population has collapsed from starvation. It simply ran out of food.

There are other factors involved; there are differences in the way the insects work on different host trees. The effect is more severe on Douglas fir, for example, because the insect can go from the young larvae stage directly to the older needles. On the grand fir, true fir, and white fir it doesn't work that way.

Now to answer the first part of the question. Particularly in Columbia County, Washington, the population has not collapsed in all areas. Some of the evidence of our egg-mass surveys shows that we apparently have some new, "satellite" outbreaks over that part of Washington.

STATE OF KNOWLEDGE, WORK IN PROGRESS, AND RESEARCH NEEDS FOR THE DOUGLAS FIR TUSSOCK MOTH

Robert E. Buckman
Director, Pacific Northwest Forest and Range Experiment Station
U.S. Forest Service, Portland, Oregon

INTRODUCTION

MR. KORP: Our third speaker from the Forest Service needs a little more time on the program. I understand Dr. Robert Buckman will cover research. Dr. Buckman is the Director of the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Dr. Buckman——

DR. BUCKMAN: Thank you, Henry. I will provide the reporter with a slightly edited version of this talk, if it will ease his burden.

I would like to introduce four of my associates who are present. They are at the forefront of their respective fields in tussock moth research. Ken Wright is Assistant Director of the Pacific Northwest Forest and Range Experiment Station, in entomological research. Dr. C. G. (Hank) Thompson—Insect Pathologist, U.S. Forest Service—is the project leader of our search for biological (microbial) controls for Douglas fir tussock moth. Richard Mason—Research Entomologist, Pacific Northwest Forest and Range Experiment Station—is working with Boyd Wickman in population dynamics and growth impact studies on Douglas fir tussock moth. George Martin heads our aerial applications research project (he was very active in tussock moth work last summer) and earlier was involved in Mirex research and the fire ant problem in the Deep South. I hope you will consult these people, both formally and informally, throughout the day's discussions.

I represent the research arm of the Forest Service and, more particularly, the Pacific Northwest Forest and Range Experiment Station in Portland, Oregon. I am also representing the director of our sister station to the south, the Pacific Southwest Station in Berkeley, California.

PRESENTATION

I appreciate this opportunity to talk to you about Forest Service research work in progress and research needs for the Douglas fir tussock moth. I obviously do not have to underscore the importance of the pest or the damage it has caused the past several years in the States of Oregon and Washington. Fortunately, the organization I represent can present a rather comprehensive summary of where I think we stand and what we need to do next in terms of research.

The Pacific Northwest Forest and Range Experiment Station has been committed to intensive studies on microbial controls for the tussock moth since 1964, and on population behavior and impacts since 1966. We have also started a cooperative research program to identify the female sex attractant of the insect. The Pacific Southwest Station has been screening chemical insecticides for use against the tussock moth since 1965. We are now well along on several lines of work and are initiating cooperative studies with other organizations and universities.

What We Know About the Insect, Its Damage, and Control

Biology. The Douglas fir tussock moth is a defoliator of Douglas fir and many of the true firs in western North America. Tree damage takes place over about a 60-day period in the summer, when developing larvae feed on the foliage. Pupation usually occurs by mid-August. In September, the adults emerge, mate, and lay their eggs in masses at the pupation site. Hatch occurs in spring or early summer.

Ability To Detect and Evaluate Populations and Predict Trends. The tussock moth is native to western forests. Outbreaks have been recorded periodically since the beginning of this century. Its populations fluctuate widely. At low population densities it is virtually undetectable, whereas at high densities it is capable of causing complete tree defoliation in a single season. Fortunately, populations do not erupt to outbreak status in 1 year, but require several seasons of buildup before defoliation becomes conspicuous. Incipient outbreaks can usually be detected a year or two in advance of serious damage by sampling tree foliage for larvae.

The presence of tussock moth in a stand does not necessarily mean an outbreak is imminent. However, reasonable predictions can be made by relating population levels to the expected rate of population change for a given set of circumstances. Once a population erupts to outbreak status, defoliation may be conspicuous for 2 more years. The total outbreak cycle from release to *complete* collapse appears to last from 2 to 4 years.

Impacts. The effects of tree damage from tussock moth defoliation is well known for white fir, but less is known about the other principal hosts—grand fir and Douglas fir. Grand fir is very similar to white fir, and we may expect that damage will be similar. However, Douglas fir is another story. Data from last summer's studies indicate that this species suffered more severe defoliation and tree killing than the true firs. It is too early to tell if top kill and growth loss will also be more pronounced.

Further, there were strong indications that the presence of Douglas fir in a mixed stand could influence population survival during the decline phase of an outbreak and, thus, increase damage on other species like grand fir and even ponderosa pine, a nonpreferred host. The larger the component of Douglas fir in a stand, the more severe these effects seem to be.

We know less about the long-term effects of tree damage on stand productivity, seed production, fire hazard, watershed values, and, ultimately, stand recovery. However, we do have study plots in white fir dating back to 1937 that can be used for reference points in future research.

Control. Prevention of tussock moth outbreaks can only come through an integrated program of pest management based on a comprehensive understanding of the tussock moth population system. Currently, there are no proven ways to prevent outbreaks either by silvicultural techniques or by biological methods. Once an outbreak has erupted, however, there are good opportunities for suppressing the population with chemical insecticides or microbial agents before serious tree damage occurs. At the present time, no insecticides are registered for tussock moth control. Four materials—Zectran, Dylox, Sevin, and Bioethanomethrin—have shown various degrees of success in field testing. DDT is generally recognized as the most effective chemical control, although hard field data are scarce and the material is currently banned from use. A nucleopolyhedrosis virus disease and a bacterium, *Bacillus thuringiensis*, have both recently been field tested with considerable success. After further testing in 1974, these microbial materials may be ready for registration by 1975.

What Is Being Done in Research and What Is Needed

Population Dynamics and Impact. Most forest insect problems are essentially problems in population dynamics, and this is true for the Douglas fir tussock moth. As a rule, tree damage is directly related to the number of defoliating caterpillars. Thus, our research objectives have been to determine tussock moth population levels, to understand how they change over time and in different places, and to relate the levels and changes to tree damage. Because of the "feast or famine" characteristic of tussock moth population fluctuations, entomologists have often been without natural local populations to study; thus, they have had to conduct investigations in other regions.

In early population studies, an effort was made to develop adequate field-sampling methods in order to quantify and standardize population assessments. The next step was to collect data from as many known tussock moth populations as possible. We now have data from separate outbreaks in three different States which tell us a great deal about tussock moth populations and tree damage. There are patterns of population change, infestation distribution, and impact that are similar in all outbreaks. Entomologists are now working on a preliminary empirical model to predict population trends and damage and simulate the results of alternative control strategies.

To strengthen our effort using this approach, information in the future will probably need to be of a more fundamental nature than previously required. For example, recent studies have shown that fir forests on the warm, dry end of the scale have higher population densities of tussock moth and are more susceptible to severe defoliation than those on cool, moist sites. However, we know very little about temperature and moisture effects on tussock moth behavior, development, and survival, even though these could be factors that restrict or release an outbreak.

Similarly, Douglas fir in the Northwest is a favored species for defoliation, and its proportion in a stand could substantially affect the trend of an outbreak—yet our research is just beginning to look at those relationships. Generation survival has been recorded numerous times in different situations and appears to be fairly well understood, but entomologists still have not been able to identify the cause of most of the population fluctuations.

Considerable data are still needed for a comprehensive understanding of tussock moth population dynamics and impacts on the forest. Much of the information must come from multidisciplinary studies in population and community ecology, population genetics and behavior, bioclimatology, tree physiology, and ecosystem analysis.

Specifically, we plan to pursue the following lines of investigation this coming year:

1. Host phenology and tussock moth development
2. Dynamics of population change and foliage loss
3. Tree damage and stand susceptibility
4. Analysis of climate and population trends

Development of Microbial Insecticides. Formulations of two microbial agents, one a nuclear polyhedrosis virus and the other the bacterium, *Bacillus thuringiensis*, were tested against the Douglas fir tussock moth last summer. Various treatments were applied by helicopter to small, 20-acre field plots on the Wallowa-Whitman National Forest, about 24 miles northeast of Enterprise, Oregon.

Preliminary results showed virus applications were highly effective in reducing tussock moth larval numbers. This, in turn, resulted in significant foliage protection; foliage loss in treated areas was confined mainly to the new needles. The bacterium proved comparable in effectiveness when applied in an experimental molasses formulation, but was considerably less effective when applied in a commercial formulation.

Final evaluation of the 1973 field tests is not complete, but the results indicate that both *Bacillus thuringiensis* and the virus have very good potential for control of the Douglas fir tussock moth (table 1). However, there are still too many unsolved problems relating to formulation and application techniques to consider either material for operational use in 1974.

Table 1.—Preliminary results, aerial spray tests of microbial materials for control of Douglas fir tussock moth: northeast Oregon: 1973

Spray material tested	Average postspray population reduction[1] after 35 days, percent
Low virus (100 billion polyhedra per acre)	95.9
Low virus plus sunscreen	97.3
High virus (1 trillion per acre plus sunscreen)	99.9
Combination of low virus and *Bacillus thuringiensis*	98.5
Bacillus thuringiensis in molasses formulation	98.0
Bacillus thuringiensis in biofilm formulation	80.3
Control	56.6

[1] Each spray material was replicated on three plot areas with 15 sample trees each; thus, each average figure shown is based on counts from a total of 45 sample trees.

So far, the two materials have only been shown effective when applied to 20-acre plots. We need to do considerable additional field testing before we can progress from these limited plots to an operational basis. Similarly, problems remain to be solved in developing mixing and handling techniques and a suitable carrier formulation.

We strongly recommend that an expanded research and development program be undertaken with the goal of having both materials fully tested and registered by 1975. Work should be undertaken to—

1. Develop a technique for bulk-mixed formulations which can be applied with conventional spray systems.

2. Conduct pilot-control tests, in various parts of the tussock moth range, to further test the virus and *Bacillus thuringiensis* formulations. Such tests would also help train field personnel in the handling and use of microbial materials.

3. Conduct additional field and laboratory experiments to develop improved formulations and methods of application.

4. Contract virus production for pilot-control tests and other future needs and to develop industrial virus production capacity. To produce and stockpile enough virus to treat 200,000 acres of future outbreaks would probably cost $1 million to $1.5 million.

A matter of key importance to development of microbial insecticides is establishment of protocols and procedures for safety testing against nontarget organisms, as required for registration for operational use. Several costly tests have been contracted, and complete safety shown. Establishment of all protocols needed to satisfy registration requirements is urgently needed.

Development of Chemical Insecticides. While microbial control agents look very promising and we plan to concentrate considerable effort on their development in 1974, we have learned through past experience that it is risky to depend on a single method of control. The Forest Service is also working to develop new chemical pesticides to replace DDT.

The chemicals we are looking for must meet several criteria. First, they should be highly specific to the tussock moth and reasonably safe for use around other forest wildlife. They should have little or no persistence, be safe to handle, easy to apply, reliable and, of course, they must be acceptable for registration.

The Forest Service's procedure for developing new chemical pesticides begins with our Insecticide Evaluation Project at Berkeley, California. Here new materials are screened against laboratory colonies of the desired insects and, if they look promising, safety tested to obtain information which will ultimately be needed for registration. Those which successfully complete the screening program are supplied to our Aerial Application Lab at Corvallis, Oregon. Here we develop and test the methodology and techniques for aerially applying the candidate materials. Next, candidate materials are field tested on experimental plots of 20 to several hundred acres.

Finally, they are ready for pilot-control tests in which they are applied to much larger areas, using the same aircraft and procedures which would be used under operational conditions.

In 1973, four chemicals had successfully completed the first three stages of testing and were ready for field experimentation. These were—

Sevin—a pesticide commonly used in agriculture, which has also been successfully used against the gypsy moth in eastern United States

Dylox—also widely used in agriculture

Bioethanomethrin—a synthetic pyrethrin, a material which has been found to be exceedingly toxic to the tussock moth, but which is still in the early stages of development

Zectran—an insecticide that has been successfully used for control of other forest defoliators, such as the spruce budworm

The results of the 1973 field experiments were encouraging in that the materials were effective in killing tussock moths. However, none of them prevented serious defoliation. The materials gave mortality ranging between 52 and 74 percent when applied once. When two applications of Zectran and Dylox were used, population reduction increased to 86 to 90 percent. Despite this degree of control, considerable defoliation still occurred on all the plots.

We feel that several of the materials showed considerable promise, and with some work we should be able to improve their effectiveness. However, none of the materials is ready for operational use. In 1974 Forest Service Research and Pest Control teams plan further field tests with at least two of the materials to test new methods of application and different control strategies.

Sex Attractant Research. The current outbreak of Douglas fir tussock moth has forced us to focus attention on a more sensitive and reliable means to detect pest populations before they are in outbreak phase. Adult female tussock moths emit a sex attractant or pheromone which attracts males. Chemical identification and synthesis of this attractant could provide the needed mechanism for a highly sensitive tussock moth monitoring system. Male-trapping systems, baited with the sex attractant and distributed over our forest lands, could provide early warning of tussock moth population buildups a year or more in advance of any major defoliation.

Since July of this year a team of scientists from the Pacific Northwest Forest and Range Experiment Station and the Oregon Graduate Center at Beaverton, Oregon, have been working on identification of the tussock moth attractant. This is the same research team that successfully identified the sex attractant of another forest insect, the European pine shoot moth. The work is cooperatively funded by the Forest Service, the State of Washington, and the forest industry. Chemical analysis has begun on an initial batch of natural female attractant extracted from 7,000 female tussock moths. Progress has been made toward chemical purification of this extract and chemical characterization of the attractant. Plans call for rapid acceleration of the search for this sex attractant. Potential use of the attractant as a *control* strategy should also be investigated.

Development of a Pest Management System. The ultimate purpose of research on the Douglas fir tussock moth should include a plan to concurrently manage the insect and the forest system in which the tussock moth interacts. As our understanding of insects and forest ecosystems expands, we should be able to do this. However, for the short term we need a coordinated research and development effort similar to the gypsy moth program in the East. The general objective of such a research and development program would be to devise strategies to manage tussock moth populations at levels to prevent serious economic loss and minimize environmental degradation.

In 1974, the Pacific Northwest Experiment Station plans to devote 9 scientist man-years to tussock moth research at a cost of over $315,000. In addition, we have requested $239,000 in supplemental funding to prepare for and conduct field-oriented studies and tests. Work would be done on improving spray formulations and application technology, accelerating the pheromone research, and determining the factors influencing population dynamics and management of the tussock moth.

We have already spent more than $2 million on tussock moth research and can expect to spend $4 million to $6 million more before we have a fully operational pest management system for the tussock moth. This total cost of $7 million to $10 million is comparable to 5-year pest-management programs underway on other forest pests.

Summary

In conclusion, I would like to emphasize that it takes a lot of time, manpower, and money to do the kind of research that is needed. In this recent outbreak, we started with several years' backlog of research and insecticide testing and we still did not have sufficient knowledge to manage the situation. We are gaining invaluable information on population dynamics, impact, and control during this outbreak. Our research program is continuing and, in many cases, is very close to providing the information needed for good pest management. Assistance is needed from other agencies and universities. But, long-term management of the tussock moth will require a better understanding of causes of outbreaks and development of comprehensive pest-management strategies. We feel that with the proper support, this can be achieved within 3 to 4 years by means of a cooperative and coordinated research and development program, involving a broad spectrum of specialists and organizations.

DISCUSSION

MR. KORP: Thank you very much, Dr. Buckman. Any questions of Dr. Buckman?

A VOICE: Dr. Buckman, in the experimental evaluation of the chemicals and biological control materials of the past year, why was DDT not included in the check plots?

DR. BUCKMAN: With the benefit of hindsight, we wish that DDT had been used as a comparison. I think our attention was riveted to the environmental impact statement which requested DDT for operational use. Next year we would like to include DDT.

A VOICE: You mentioned that you were developing empirical models to predict population behavior. What independent variables are being considered?

DR. BUCKMAN: I would like to call on one of my associates to answer that question, either Ken Wright or Dick Mason.

MR. MASON: It is important to remember that we are in a state of development. There are many independent variables that we do not understand. We would like to relate this problem to parasites, and I think climate is commonly used to drive a lot of them off. I do not have these data. But we do have a lot of population data in relation to the impact of the moth cycles over a period of time. This is why we call our work empirical. I do not think we can simulate fluctuation differences by weather variables yet. But this is exactly the sort of thing Dr. Buckman mentioned.

MR. CLEMENT: My name is Roland Clement. I am the vice president of the National Audubon Society. I would like to ask Dr. Buckman—who made a very polite plea for more support for research—whether there is an active group of people trying to convince the Congress that research support is essential. I am on the National Advisory Committee for Gypsy Moth Control, and I know whereof I speak.

DR. BUCKMAN: Is there active interest in budget and support of research for pest control? In the Pacific Northwest the Forest Pest Council is monitoring these kinds of things and has been effective at strengthening research programs. There has been a great deal more interest in accelerated research from groups such as the one you represent. The Forest Pest Action Council has been effective in supporting such programs.

MR. LAWRENCE: Bob, are you relying on in-house expertise in your model building, or are you seeking consultants?

DR. BUCKMAN: Are we relying on in-house expertise to determine these models, or are we seeking help elsewhere? I want to clarify that a bit. The Experiment Station has been very active in tussock moth research for nearly a decade. We have developed some cooperative working relationships for this particular forest pest, and our cooperative relationships are even stronger for other forest pests. I would like to refer the question of developing a predicted model for this pest to Dick Mason.

MR. MASON: Again we are faced with a current problem. We have explored a number of different possibilities. We have our own bionomics answer, but I have been told that these consultants are not easy to come by. We are considering, for example, a closer association with the International Biological Program (IBP) at Oregon State. We do have the expertise and we have considered not contracting outside expert services. Whatever happens, there will probably be a group effort because we will be working with the IBP or with our own people. It is a very important effort. We have a lot of data and we feel that the best approach to get at these data is through models.

MR. COX: My name is Royce G. Cox, Northern Rocky Forest Pest Action Council, Lewiston, Idaho. I have something that I would like to put into the record with respect to developing sex attractants for the tussock moth. Our council, with some financial and personnel help, is involved in a similar program to that of the Pacific Northwest Station—isolation of identifiers for the Douglas fir tussock moth.

OREGON'S CONCERNS ON THE DOUGLAS FIR TUSSOCK MOTH INFESTATION

J. E. Schroeder
State Forester, Oregon Forestry Department
Salem, Oregon

INTRODUCTION

MR. KORP: Our next speaker will be J. E. Schroeder, who is a State Forester from the Oregon Forestry Department, in Salem, Oregon.

MR. SCHROEDER: Thank you, Mr. Korp. Speaking as a State Forester of Oregon, and anticipating, somewhat, the types of papers to be given before us, I have tried to approach some of the concerns and problems that we have here and in Oregon. First, I would like to thank the State of Washington and Don Hopkins for making this time available. Mr. Hopkins changed some time that was originally assigned to the State of Washington.

PRESENTATION

I am J. E. Schroeder, State Forester of Oregon's Department of Forestry, 2600 State Street, Salem, Oregon 97310. I am here this morning on behalf of the State of Oregon, acting through its Board of Forestry, concerned with all the tussock-moth-impacted lands in Northeast Oregon, and with particular concern over the 558 private landowners in Northeast Oregon on whose lands the Douglas fir tussock moth has brought destruction.

In my time allotment, I will make my comments pertinent to Oregon and the Department of Forestry's problems. But I want to be on record as endorsing those needs for research to control this infestation as well as to be prepared for future potential insect epidemics, as outlined by Dr. Robert Buckman, and which will again be referred to by Dr. Carl Stoltenberg.

Oregon law charges me with the responsibility of conducting insect surveys and applying control measures deemed necessary on local government and privately owned forest lands. I am further charged with the responsibility of fire protection and of planning and facilitating reforestation of these forest lands in Oregon. But as the result of the decision last spring to deny use of DDT, I stand here today unable to carry out my legal and moral responsibilities to the State and to these frustrated private landowners.

As you know, we first became aware of a Douglas fir tussock moth outbreak of epidemic proportions in 1972. In that year, 196,810 acres of forested lands in the Blue

Mountain area of Oregon and Washington were partially or totally defoliated by the tussock moth. In the spring of 1973, we came to you with all the facts at our command, asking for the use of DDT against the tussock moth. Our past record of the use of DDT was a clean, documented one. Carefully controlled applications of DDT had been used to control the spruce budworm in the 1950's and the hemlock looper in 1962. The U.S. Forest Service had used DDT to control a smaller tussock moth infestation in Oregon in 1965. Our conservative projected defoliation figure for 1973 was 450,000 acres. Beyond this immediate loss, we were concerned about the long-range environmental, economic, health, and fire-hazard impact this infestation would have on the State of Oregon.

Despite our excellent past record and alarming projections from some of the better known forest entomologists in the country, EPA denied our request to use DDT.

The result has been the visible defoliation in part or total of over 689,760 acres of forest land in Oregon and Washington. The result has been major damage on 109,000 acres of private land in Oregon and an economic impact to 558 Oregon landowners and the Northeast Oregon timber-products industry. The result of the overall damage to public as well as private timberlands is a 20-30-year setback in the tree-growth cycle, increased fire danger for up to 20 years, a loss in forest esthetics, environmental damage, and an increased health hazard. This is going to have a substantial impact on a sizable portion of Oregon.

It appears we may again need to ask the Environmental Protection Agency for conditional use of DDT in 1974 to curb further defoliation and tree loss. Others here today will testify that there is no evident alternative for DDT in 1974. In the words of Oregon's Governor Tom McCall,

> We've seen enough hemming, hawing and side-stepping. We definitely need an answer. . . . It is mandatory that DDT be authorized for emergency use in this situation until it can be shown absolutely that another method of control is at hand. This gambling with this magnificent resource must be stopped.

Last year we made every effort to work in cooperation with EPA and others to the best of our ability. We were still unsuccessful. Was our request not well enough written or factual enough? Was insufficient evidence presented? Looking forward to 1974, what must we present to receive favorable response from you?

As we near our self-imposed deadline for a request to you for conditional approval of the use of DDT, I still find myself with unanswered questions about your decisionmaking process. Should we again apply for authority to use DDT under section 18. Or should we address ourselves to section 3 in response to our special considerations to the private landowner, particularly those with small ownerships which, if not treated, are apt to be impacted in a degree inconsistent with broad area averages? What are your guidelines for measuring the full impact of this infestation on the landowner, the environment, and the economy? How do we relate and weigh the esthetic, economic, environmental, and recreational values against using or not using DDT? What is a reasonable cost-benefit ratio? We thought the cost-benefit ratio of 13.4 to 1 presented in last year's statement was pretty impressive. What criteria were used in deciding if our cost-benefit ratio was valid? We need to have answers from EPA for these considerations, particularly if our best evaluations are to be reevaluated by some criterion or rule we have not been provided.

And I look at this year's events with other troubled questions on my mind. The Federal Government speaks of a policy to decentralize the Federal bureaucracy in favor of increased local control. This has not been so in the tussock moth crisis. A decision was made by people in Washington, D.C., not local staff, that the moth population would collapse, contrary to evidence provided by Oregon's best entomologists. These same people, away from the local scene, underestimated the economic effect of the devastation of these forested lands to Oregon. Because the decision was made away from the Pacific Northwest, there was inadequate consideration given to the impact of this loss to the small landowner managing his forest as an investment. Finally, the decision at the national level did not recognize Oregon's responsible use of DDT in the past. These actions clearly do not demonstrate to us a decentralized Federal Government, more responsive to the needs of the people. Is this going to continue to be the procedure followed by EPA on future issues of this kind?

One final concern last spring was that no practical form of appeal to your decision was available to us. We had no recourse except by way of the Federal courts to get a reconsideration of the decision that was made. This process forecloses any change of decision that would be within the time frame for control action.

Another question that I have which concerns the decisionmaking process is relative to decisions which EPA has made authorizing the use of DDT with certain agricultural crops. Inability of a farmer to use a needed control on his bean crop may mean 1 year of crop failure. Inability of a forester to use an available tool (DDT) on this tussock moth infestation means 20-30 successive years of crop failure, and from 1 to 30 years of economic reverberations on the economy of Oregon. Did you view the long-range consequences of this situation, or did you apply the criteria of a failure of a summer crop to this situation?

There are many more questions troubling me and our department as we face the possibility of again formulating a request for DDT. We just do not know enough about your decisionmaking process so that we can prepare the type of application or statement that will meet the criteria or standards that you will use in judging the merits. Is it possible that we can sit down together and talk about how we can improve our techniques to provide you with the information you need to thoroughly and consciously carry out your evaluation and respond to our needs as expressed in our application, supported by the best information we know how to provide? We should not be two teams playing a different game; we are not even worthy opponents. We are two public agencies, each with a vested interest in doing what is best for Oregon and for the Nation. Why can we not sit down, define the rules, and work toward a common objective?

But the impact statement, the decision, and the eventual fall of the tussock moth population are only a means to an end. The real problem we face is the rehabilitation of the devastated area.

Oregon faces a massive rehabilitation, reforestation, and fire-control problem created by the tussock moth. Some 106,316 acres of private lands in Oregon must have increased fire protection for the next 20 years. Detection, prevention, initial-attack, and mobilization programs must be stepped up. Construction of snag-free corridors, access roads, and fuel breaks must begin.

The Department of Forestry is responsible for fire protection on the private land. But there are no asbestos walls around these lands. The impact of fire on adjacent Federal lands has an impact on the private lands. The possibility of a wildfire starting in the tussock moth area and spreading to unaffected areas could create an even greater impact on good timber, towns, and forest dwellings. One need only consider the "what if's" of the Rooster Peak fire near La Grande this summer to understand the potential for disaster.

In addition to fire control, some 32,900 acres of private land require rehabilitation in the form of hazard reduction, site preparation, and cutting. The costs of these projects are well beyond the means of the 558 landowners affected. These people have watched their timber being damaged or destroyed by a decision over which they had absolutely no control. These people have seen their financial hopes for a college education for their children, a nest egg for their retirement, and a supplemental income, dashed in a summer by the uncontrolled tussock moth. Because they have no funds for rehabilitation of their lands, the lands may remain unproductive unless some source of revenue is discovered. Should these Oregonians have to pay so dearly for a decision beyond their control or appeal? We need to immediately find financial incentives to make this rehab work successful.

But above all other considerations, let us be sure that this catastrophe never occurs again. Let us rethink our policies of banning effective chemicals before substitutes are developed. Let us work toward the development of alternatives to persistent chemicals. And let us come to the conclusion, if need be, that occasionally there may not be found effective alternatives, and that occasionally, there may be need for restrained and controlled use of these chemicals.

I have appeared here today to present Oregon's concerns on the Douglas fir tussock moth infestation, to outline some of the seemingly unresolved issues and problem areas that need further definition or clarification, to review the long rehabilitation job ahead, and to offer our assistance to work with you. Oregon and the Nation cannot afford the current situation to continue. Together, we must search out the ways we can both meet our objectives of serving the citizens of this country.

DISCUSSION

MR. KORP: Mr. Schroeder, truly, thank you very much. You did raise a lot of questions. Do you have a second copy, Mr. Schroeder? I would like to have it, not only for the reporter, but to reply to you.

A VOICE: I have a question that I think is germane to this issue. Often we hear of a 20-30-year cycle. In 1933 we had a fire in Columbia County. It took out a good portion of a certain timbered area, and that area is still barren. It has not been reestablished to date. Second, a good part of the trees that are being killed would never have grown in 20-30 years on that side of the State; they would over here. Over there, we are talking about more than a lifetime. Why don't we adjust to the facts and talk about 50 to 60 to 100 years, instead of 20?

MR. SCHROEDER: We are stating here that an average age of many of the trees that were damaged in the private owners' class were of younger age. The big point that I would reiterate is the difficulty in establishing any forest in many of these areas because, as a whole, many of them are adverse sites. We do not now have the technology or the know-how to discuss this problem in detail.

MR. KORP: All the comments have been noted for the record.

FOREST INSECT CONTROL THROUGH RESEARCH

Donald R. Hopkins
Chief Deputy Supervisor, Department of Natural Resources
State of Washington

INTRODUCTION

MR. KORP: Our next speaker will be Mr. Donald R. Hopkins, Chief Deputy Supervisor, Department of Natural Resources of the State of Washington.

MR. HOPKINS: Thank you, Mr. Korp. I believe most of you will agree that the time I donated to Mr. Schroeder was well used. We have the same concern; but, in discussing the program, we decided that he would discuss these types of impact and that I would discuss research.

PRESENTATION

At the risk of repetition, I will discuss research needs and their proposed accomplishment as they relate to the control of forest insects. Our primary topic for the day has been the tussock moth. I would like to expand the base of discussion to include research related to general control of forest insects. In doing so, I believe it is well to consider the importance of wood resources in light of our current energy crisis. Local reports indicate there is an increasing demand for firewood, spurred by concern over oil-related fuel shortages. Wood also provides additional electrical energy when waste products are used to fuel steam generators. For example, Simpson Timber Co., in Shelton, uses sawdust, bark, and edging to produce power surplus to their needs to help relieve the electrical shortage.

Contrary to some comments, wood is not a vanishing resource. We will always have trees. The question as to adequacy of supply, however, depends on our management efficiency, including the effectiveness of our insect-control programs.

U.S. Forest Service inventory surveys indicate that insects and diseases destroy more wood each year than wildfires. Unfortunately, data are not available to show the amount of wood that is destroyed by each agent, but it is estimated that 15 billion board feet of timber are lost to fire, insects, and diseases each year. If we assume that 8 billion feet are affected by insects and diseases, and that half of this loss results from insect attack, we are faced with 4-billion-board-foot loss annually from insects alone—enough fiber to construct 400,000 homes.

Practical control methods have been developed for very few forest insects, particularly the exotic species. As a result, those that are imported from other continents too frequently find native species ideally suited for their voracious appetites. Unfortunately, on being transplanted to our forests, these timber destroyers do not bring their native predators with them. Two local examples are the balsam woolly aphid, which is destroying our silver and grand firs in western Washington, and the larch casebearer that is causing tremendous growth losses in our larch stands of eastern Washington. Natural predators that control these insects in their home country have been introduced on a limited basis, but have not successfully reduced populations of either species. More research is needed to carry on these types of biological-control programs.

In addition to these foreign invaders, we have ample numbers of native insects that periodically overcome natural population-control mechanisms and explode into forest-devastating epidemics. Some, such as the bark beetles, for which there are currently no effective biological or chemical controls, annually destroy millions of board feet of prime timber. In some instances, silvicultural management, such as thinning excess trees in overstocked ponderosa and lodgepole pine stands, prevents the initial buildup of insect populations. Prompt removal of blowdown, fire-killed, and disease- and defoliator-damaged trees can also reduce bark beetle impacts. Obviously, we have a long struggle ahead to convert current research leads into effective beetle-control practices.

The only group of forest insects for which economic controls have been developed are the defoliators. Until the manufacture of DDT and its subsequent application in the late forties and early fifties, there was no practical method of reducing the damage that these insects caused in our Pacific Northwest forests. DDT is representative of the chemicals that have been used to control forest insects, in that it was initially developed for agricultural use and subsequently was found to be effective in solving forest insect problems. Here the motivating insecticide-development forces were the profits that the chemical companies anticipated from sale of their products to farm users. To date there are no chemicals that were developed specifically for control of the forest insects by the pesticide manufacturers.

Several years ago, Weyerhaeuser Company explored the possibility of selective forest pesticide development with three of the larger chemical firms. Each of these corporations, after investigating the situation, arrived at the same conclusion. The high cost of developing and registering such products eliminated possibilities of these firms producing them at their own expense. We are told that these development costs vary from $3 million to $8 million per usable product; also, that it takes from 6 to 8 years to develop them to the point where they are registered and their use is permitted by the control agencies.

When you review these costs and time factors in conjunction with the spasmodic use of forest-insect-control materials, it is obvious that research development needs cannot be met by the commercial firms alone. Who, then, should share the responsibility for development of coordinated pest-control programs that include improved surveillance, better prediction of epidemic conditions, discovery of usable biological and chemical control agents, and development of effective application procedures? I propose that a greater portion of these costs be financed by the Federal Government, with the State and private sectors contributing in ratios proportional to the benefits each expects to receive. When biological-control materials or chemical pesticides are involved, it is logical that the chemical companies who could profit from their production would also participate.

As you have heard, the U.S. Forest Service has been successful in developing a virus that offers promise for tussock moth control. This has been a time-consuming and costly program, but fortunately one that offers great promise for the future. In essence, the total cost was borne by the Federal Government with limited contributions from State agencies. The Forest Service should now accelerate its insect research programs, and State and private contributions should be increased with prorated investments based on the anticipated benefits.

Looking at a formula approach to this problem, it seems reasonable that the Federal Government, through the Forest Service, should contribute to this research in ratio to the lands that are managed by the various Government agencies (including those properties managed by the Indian Service) plus acreage in small private ownerships. In the latter case, it is impractical to expect individual owners to participate directly in financing such development. I recommend that the State agencies and the large industrial forest landowners provide development financing representative of the respective interest of each owner as measured by their potential returns from the research accomplishments. For example, research of national significance might be prorated using commercial forest land ownership as a base.

Commercial forest land ownership:	*Acres*
Federal Government (including Indian lands)	107,108,000
States, counties, cities	21,422,000
Industrial owners	67,341,000
Farmer and miscellaneous private	296,234,000

Based on these data, financing would be as follows:

Federal, 22 percent
State, 4 percent
Industry, 14 percent
Farmer and miscellaneous private, 60 percent

As I mentioned previously, much of the high cost of developing insect controllants results from constantly increasing registration costs. Since the Environmental Protection Agency administers the program, I recommend that costs attributed to these activities be shared by that organization, particularly when uses of proven chemicals are canceled and effective substitutes are not available.

The director of the State of Washington Department of Ecology, Mr. John Biggs, at a recent meeting of the Washington State Pesticide Control Board, recognized the need for more government participation in these programs when he recommended that positive action be initiated to find DDT substitutes and, if necessary, that the board and the State should assist in obtaining their registration.

As finances become available for research projects the question, Who shall do the research? must be answered. The obvious response is that investigations should be conducted by those best qualified to solve individual problems. Resources, whether they are dollars, manpower, or facilities, must be allocated with this principle in mind. Investigations could be conducted by scientists currently employed by existing State, Federal, or private agencies and public institutions. Or, the funds could be allocated on a contractual basis to acquire the needed expertise and facilities.

An example of how this can be accomplished was provided recently. The Pacific Northwest Forest and Range Experiment Station, the States of Oregon and Washington, and industry joined forces to finance development of the European pine shoot moth pheromone that will be used for surveys this coming year. There are also some indications that this attractant may have limited use for control purposes. At present, a similar effort is underway to identify the pheromone of the tussock moth; if successful, its use might make it possible to detect potential tussock moth outbreaks at an early stage. This detection procedure, coupled with future control materials such as the virus, offers a possibility for minimizing damage these insects cause in our western forests. Identification of the pheromone, in both cases, was contracted to the Oregon Graduate Center in Portland, Oregon. The center developed its expertise in identifying pheromones as a result of an interest on the part of the institution's administration and their dedicated scientists.

It is paramount that decisions made by agencies delegated the responsibility of controlling pesticide use are based on the best research data available. This necessitates constant reexamination of legal requirements and procedures that are adopted ostensibly for the protection of people as well as the environment. Reviews must include examination of past legislation such as the Delaney Act, which prohibits presence in food of additives declared to be carcinogenic. The problem inherent in this legislation is that, at the time of its enactment, equipment available for detection of additives was much less precise than that obtained with today's machines. In addition, current carcinogenic testing procedures need reevaluation to establish no-effect levels for such additives. Realistic evaluations will provide needed protection without eliminating use of pesticides that in fact do not present a hazard to health or the environment. It is ironic that current procedures result in zero tolerances of carcinogens in foods, but permit the continued use of vitamin A and aspirin, which have a much higher carcinogenic potential.

It is equally important that decisions affecting pesticides be based upon approved use of materials and not their misuse. For example, an arbitrary decision in 1961, at the time the cranberry crop was being harvested and marketed, almost destroyed the cranberry industry. Subsequent examinations proved that very few of the cranberries were affected by what proved to be a misuse of the chemical Aminotriazol. Had the situation been managed properly, necessary protection could have been achieved without causing chaotic conditions for both producers and consumers.

I feel personally that the same situation occurred in conjunction with DDT. The ban was unwarranted. Improved regulations to control overuse, nonessential uses, aquatic uses, and misuse could have provided the desired environmental protection and avoided unnecessary adverse impacts resulting from its nonuse.

An example of another agency action that has been costly and disruptive to industry and the public occurred in conjunction with phosphates. Recommendations that they be replaced by a substitute have been revised, and phosphates are now accepted as an ingredient in our detergent products.

An outstanding example of results of public reaction to press repetition of false statements, regarding use of herbicides, occurred in conjunction with a U.S. Forest Service brush-spraying project near Globe, Arizona, in 1961. Subsequent costly investigations proved the original reports were completely unfounded, but public acceptance of the initial news releases still affects reactions to continued herbicide use.

My purpose in citing the above examples is to support my plea for a balanced, scientific investigation and reporting of facts before decisions are made by program administrators.

In conclusion, I reemphasize first our need for more support of forest-insect-control research by Federal and State agencies and private landowners, and, finally, that provisions governing development and registration of biological and chemical control agents be constantly evaluated and revised to assure achievement of effective forest insect control with minimum adverse impacts on nontarget resources.

DISCUSSION

MR. KORP: Thank you, Don. The reporter will appreciate a copy of your paper. I know there are some questions.

MR. KINGSTON: My name is Charles Kingston and I represent the Oregon Times. Now I want to check something right here. In the 1973 paper that was published by Pacific Northwest Experiment Station, why is it that the public has been told that DDT has not worked in the Stanislaus National Forest where you have controls? Your Administrator, Mr. Train, says he wants the public to be involved. For them to be involved, they have to know what is on the tapes, and I would like to have the answers. I did ask this question the day before you came, Mr. Korp. I got this answer: that this was because the moths were in their third year; and yet DDT was asked for, of your agency, in the third year in the La Grande area.

MR. KORP: Are there any other comments?

MR. HAZELTINE: My name is Bill Hazeltine. That question was asked yesterday at Sacramento, and there was a discussion about unpublished data. There are people in California who can probably answer your question.

A VOICE: I was going to raise a similar question, because at the Forest Pest Control Action Council meeting in Sacramento there really were no data on DDT application. The studies presented yesterday by Carroll Williams showed—and this is a laboratory application of field formulations—that DDT was not the best insecticide in the field tests that were run. I understand that there was a problem with the formulation and coverage, but it is our feeling that the concise data are not there. That is why we have been confused by the continual statement that DDT is not the only insecticide we have. There is a real gap in the information and the research coverage.

MR. KORP: I might point out that anybody whose remarks are not included in this oral discussion can send material to us; we will certainly include it. So don't hesitate to get in touch with us after the meeting.

TECHNICAL PROBLEMS AND RESEARCH NEEDS: WHAT ARE THEY?

Carl Stoltenberg
Oregon State University

INTRODUCTION

MR. KORP: Now I shall go on to our university people. The first is Dean Stoltenberg, from Oregon State University.

PRESENTATION

My name is Carl Stoltenberg. I am Dean of the School of Forestry, Oregon State University, Corvallis.

I have been asked to describe my university's involvement in the current tussock moth program, to identify major research needs, and to outline our position relating to solving current and future tussock moth problems. I have also been asked to explain the objectives, organizational structure, and recommendations of the Inter-Agency Douglas-fir Tussock Moth Steering Committee.

Oregon State University Involvement

Oregon State University conducts research and educational programs designed to help Oregon's people solve important resource problems. An example of these problems is the complex created by the series of tussock moth outbreaks in the summer of 1972. My university is not engaged in tussock moth research, although the major Federal research on the insect is centered on the OSU campus, with the staff of the Forestry Sciences Laboratory, Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service. Our role in this issue has thus been primarily educational.

Surveys of defoliation caused by the tussock moth in Northeast Oregon in 1972 indicated a problem of major proportion. Over 400,000 acres appeared to be infested. Public and private lands were involved. Concern over the infestation spread even further when it became apparent that a control being considered was the chemical DDT, a chemical currently prohibited for use in forests.

Immediately, questions were posed about the insect, control possibilities, the magnitude of probable forest and environmental losses with and without an insect-control

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program, and other values at risk. These were highly controversial and complex questions; available information was limited; and the facts appeared to be conflicting. Accordingly, Professors Krygier, Streeby, Witt, and Capizzi of Oregon State University decided to prepare an unbiased, factual report on the insect outbreak, the control alternatives available, the hazards for wildlife populations should DDT be used, and the opposing economic, social, and related environmental value losses if DDT were not used.

The resulting 16-page question-and-answer bulletin, "The Douglas-fir Tussock Moth—The Problem, Alternatives, and Impacts," OSU Extension Circular 821, was distributed in February and updated in March of 1973. The bulletin was intended to be a brief, accurate, and easily understood document that would enable all interested citizens to understand the major facts of the situation. The bulletin did not take a position for or against DDT. Together with the extension specialists, 12 researchers were directly involved in developing the information. Specialists consulted were from the U.S. Forest Service, the Denver Wildlife Laboratory, and the relevant departments at Oregon State University.

In addition to the publication, the university cosponsored local meetings and other educational programs to acquaint interested citizens with the problem and the facts related to the alternatives available. Once again, the role of Oregon State University in this particular issue has thus been education rather than research, advocacy, or administration.

Research Needs

We fully support the Forest Service research proposals described earlier this morning by Dr. Buckman. Recent research on this particular insect, the tussock moth, has been conducted almost entirely by the Forest Service—we believe their direct research on this insect should be given the highest possible priority.

Briefly, our view of research needs related to the present outbreaks includes the following—some of which are included in the Forest Service research effort and others of which are appropriate for universities and other research efforts:

1. Continued testing is needed by the Forest Service of the bacterium and the virus, which show such promise for future tussock-moth-control alternatives. Their formulations should be refined and their effectiveness and safety evaluated by larger scale, operational tests. Promising chemicals, particularly Dylox and Sevin should also be further evaluated in small-scale tests. (Forest Service)

2. If DDT is used, full research should be conducted to evaluate the consequences. We should discover how much such applications reduce tree damage under various insect population and forest conditions. And we should also quantify and evaluate the subsequent distribution of DDT in the environment, in food chains, and in animal populations. (Universities and Forest Service)

3. Studies are needed to improve detection and control of secondary insect infestations (bark beetles, scolytus, and others), which develop and cause further tree mortality and timber and environmental losses in moth-weakened stands. (Universities and Forest Service)

4. Field testing is needed of alternative methods of regenerating stands destroyed by the tussock moth. (Universities and Forest Service)

And to provide improved solutions to future tussock moth outbreaks, we also need—

1. Research to develop improved detection methods to locate and identify developing tussock moth populations at an earlier phase of their cycle. (Forest Service and universities cooperating)

2. Research to develop improved methods for predicting future tussock moth populations from present estimates of moth populations, outbreak history, virus counts, etc. (Forest Service)

3. Improved data on the relationship of tree defoliation to tree mortality. (Forest Service and/or universities)

4. Research to discern stand conditions which enable tussock moth outbreaks to develop, and those which appear resistant to such attacks, i.e., silvicultural control of the moth. (Forest Service and universities)

5. Improved methods for establishing loss and value impacts. (Forest Service and universities)

Our position regarding future outbreaks of the Douglas fir tussock moth and other destructive insects is that a much stronger information base is needed to avoid tragic losses such as those which have been sustained this year. We cannot expect any agency, corporation, or individual to make consistently wise and correct decisions on such critical problems when the knowledge base is so limited.

This will not be the last disaster. And the next may be even more devastating. We must invest much more heavily in research to strengthen our knowledge base—*prior* to the *next* emergency. If, for whatever reason, insect-management tools are removed, either extensive research must be immediately undertaken to develop alternatives, or we must realistically face the consequences.

Solutions to the problems associated with the present tussock moth outbreak, of course, involve much more research. To be useful, the best available information must be made available to those who are affected by the moth, and particularly to all who make decisions regarding insect control and subsequent forest rehabilitation efforts. Related communication is thus as important as the research itself, and effective solutions to this and future problems must include education and communication efforts.

And, in addition to research and education, the major investment will be in action to control the insect and to rehabilitate the devastated forest areas, hopefully returning most of them to some form of economic and environmental productivity. Such actions have already been described by others. They include accelerated construction of access roads to enable timber salvage and to reduce the hazard potential for future fire and insect explosions; increased fire prevention and control measures; tree planting with associated site preparation, seedling production, and rodent control; and specific erosion control and watershed protection measures.

Inter-Agency Committee

I should also like to respond to your request for information on the Inter-Agency Douglas-fir Tussock Moth Steering Committee.

We have learned, as well as suffered, from the discussions and frustrations associated with the tussock moth during the past year. We have learned that complex, fast-moving problems like this one require each responsible agency to respond promptly and in a very timely and closely coordinated manner with other agencies which have related responsibilities. The National Environmental Policy Act (NEPA) has further complicated agency working relationships, providing new time constraints and requirements for new data, projections, paperwork, and decision review. Briefly, NEPA requirements force closer coordination and mutual understanding of actions and requirements of other agencies.

The Northwest Forest Pest Action Council had for years provided a most useful forum for effective exchanges of information between forestry researchers and practitioners, and between agencies, industries, and schools. It is a satisfactory forum for coordination of many actions. And it provides an effective forestry voice—in legislatures and elsewhere.

But situations such as the tussock moth problem call for more finely tuned timing, understanding, and coordination of *final* decisions among the heads of the responsible agencies. Recognizing this need, the heads of the agencies involved decided to meet together to exchange information and tentative plans prior to making their final program decisions.

This Inter-Agency Committee currently includes the heads of the State forestry agencies, men held responsible by their respective legislatures for decisions related to control of insect outbreaks and related problems on private and State land—Schroeder for Oregon, Fraser for Washington, and, more recently, Gillette for Idaho. It includes the Regional Forester for the U.S. Forest Service, the man responsible for insect detection surveys and for decisions regarding insect-control programs on national forests and Federal contributions to insect-control programs on other forests—Schlapfer for Region 6 (Oregon and Washington) and, later, Yurich for Region 1 (Idaho and Montana). It includes Washington office representatives of the Forest Service and, now, the EPA, to help provide better understanding, both of local problems and of the information needs for agency decisions in Washington, D.C. It includes Hadley, Area Director of the Bureau of Indian Affairs, responsible for forests in the Colville Indian Reservation where a heavy tussock moth infestation occurs. It includes those responsible for relevant research—in this case, primarily the Pacific Northwest and Pacific Southwest Forest and Range Experiment Stations of the U.S. Forest Service, Buckman and Camp, respectively. It includes the universities involved in a related research or public education program—in this case, primarily Oregon State University, represented by myself.

I served as chairman of the initial meeting; Mr. Schlapfer has served as chairman of subsequent meetings. The initial group was small, fostering clear communication. The committee is ad hoc and not tightly structured. As others with related responsibilities were identified they were invited to participate, so their decisions, too, could be made with the knowledge of what others are doing—when—and why.

Perhaps the term "steering committee" is inappropriate, because the committee itself does not have a decisionmaking function. Rather, it is comprised of executives with decisionmaking authority for their agencies, responsible executives who realize their interdependence and want to make at least some of their individual decisions in concert with the decisions of others.

The group does not vote, nor does the group control the action of any individual within it. No participant can delegate his authority or responsibility to the group.

The committee is ad hoc, and will self-destruct with the end of the present emergency. Another emergency would likely require a committee of somewhat different composition, depending on the problem.

Committee discussions do not in any way replace public input, nor the extremely important input of industrial, environmental, and other vitally interested groups. Such inputs must continue to be obtained by the individual agencies, separately or in concert, through the Pest Action Council, public hearings, formal and informal review of proposals, etc. But the agency heads involved believe their decisions will be sounder, more timely, and better coordinated with those of other agencies, and thus their actions will be more effective as a result of this forum—the Inter-Agency Steering Committee.

Members of the Steering Committee agreed on several major points earlier this fall, namely the desirability of—

1. Accelerating research to develop alternatives to persistent pesticides. Refining the formulations of the virus and *Bacillus thuringiensis* which were effective in the 1973 tests. Testing and evaluating their effectiveness on a larger-scale, operational basis. Conducting further small-scale tests of Sevin and Dylox.
2. Seeking contingency approval from EPA for emergency use of DDT in 1974 if the fall egg-mass surveys indicate continuing dangerous population levels in any of the outbreak areas. Precise criteria for use would be specified in the application to EPA. All provisions of NEPA would be followed, and DDT would not be used unless the incidence of virus in the egg masses indicates a high population likely in the summer of 1974.
3. Improving the systems for detecting the presence and numbers of the tussock moth.
4. Continuing the Steering Committee to coordinate agency decisions.

In addition, the Committee agreed to cooperate in preparing an updated information booklet on the tussock moth outbreak, areas and values affected and endangered, control alternatives, and insect levels as of the end of 1973. This educational tool is now being reviewed and should be available next month.

DISCUSSION

MR. KORP: Thank you very much, Dean Stoltenberg. Are there any questions of the Dean?

A VOICE: Yes, I am criticizing the Inter-Agency Committee. I have criticized it in too many articles which I have sent to the EPA in Oregon, on the grounds that the

Committee has not asked for any information; the Committee does not include any of the environmental groups, unless policies have been changed. Furthermore, I had to use journalistic devices to even get to visit the Committee that was meeting at the Forest Service. Now I would like to have your response to this. Is the Committee really adequate? Why have you and your Committee not said to the public, "we have some failures with DDT"?

MR. STOLTENBERG: Number one, the Committee has not had any failures with DDT. The Committee has not done anything with DDT.

THE VOICE: You said you did not have any failures, but you knew about failures and—

MR. STOLTENBERG: Let me finish answering your question. The purpose, as I have just stated, is not to substitute as a public forum. The purpose of this group—after the individuals involved in the different agencies have had exchanges with the public and all of the different environmental, industrial, landowner groups, after they have had this kind of input—is to come together as men and say, All right, this is what I feel we have to do. My decisions have to be made in this sequence, at the time. What are you going to do? My input from Oregon, from Idaho, is as follows. My readings are these. How are you going to react? How can I coordinate my efforts with yours? So that I feel that this particular group holding public hearings is not appropriate.

MR. KORP: I would like to make a comment. I would like to avoid debate of this type. I hope you can resolve this question, and I will accept information from any group—from the Steering Committee, environmental groups, the newspapers, the public. But let's not get into this type of discussion at this meeting. We will hold hearings here in the future, when we can get some of that into the record. Now I think we have one more question.

MR. PALMENTEER: My name is Eddie Palmenteer. I am the Chairman of the Colville Business Council. I accepted your invitation to present material for the record.

I have an impact statement concerning the Colville Reservation. It explains the losses we have incurred as a result of the tussock moth infestation on the reservation. Basically, it describes our monetary losses, which have been estimated at $4 million since the infestation. It represents, approximately, 50 million board feet of timber, and our past losses include approximately 79,000 acres of reservation timberlands in which there was damage. Damage also was done on an additional 80,000 acres, for a total of 159,000 acres. We estimate that this will probably represent $500,000 a year, for many years to come, in losses to the tribe. So, if it is permissible, I would like to present this statement for the record.

MR. KORP: Thank you. We will put it in the record.

DEVELOPING STRATEGIC MANAGEMENT SYSTEMS FOR THE DOUGLAS FIR TUSSOCK MOTH

Dr. Alan Berryman
Associate Professor of Entomology, Washington State University
Pullman, Washington

INTRODUCTION

MR. KORP: Our next speaker is Dr. Alan Berryman, Associate Professor of Entomology, Washington State University, Pullman, Washington.

PRESENTATION

Dean Stoltenberg attempted, in the early phases, to try and coordinate the academic constituents of this seminar, without much success, I am afraid, because of our inability to schedule a meeting. Thus, some of the things that I wanted to say have already been said. So what I am going to try and do is address myself to the question of how can we develop strategic management systems for the Douglas fir tussock moth. This implies that we have the knowledge of the design criteria that are necessary to fulfill this kind of objective. I would like to briefly run through some of the criteria that I feel are necessary to define a pest management system of this magnitude.

First, as people have said previously, we need an efficient and effective population model which will allow us to predict when and where outbreaks of tussock moth will occur. We need this model, as well, for simulating possible management prescriptions, singly or in combination, as an alternative to costly and time-consuming field research. We need a model in order to carry out systems analysis which enables us to investigate the stability characteristics of this system and to test the sensitivity of the system to various control parameters or functions. Second, we need an impact model which relates various population levels to actual damage, that is loss in growth and mortality. Third, we need control functions that relate control tactics to short- and long-term effectiveness of these tactics and their effect on other ecosystem components. Fourth, we need cost functions which relate damage caused by the insect or the control to socioeconomic values.

The first slide[1] illustrates a possible sequence of population events that may be analogous to the tussock moth problem. This is actually a bark beetle but I think the concept holds. The functions relate the damage of the insect to socioeconomic values; that is, values in terms of timber production, recreation, water, esthetics, etc. We also have to know the cost functions that relate the costs of control to their benefits when applied to the system; that is, their cost in terms of application, buying materials, damage to other ecosystem components (fisheries, wildlife, human health, etc.) and also the benefits that they produce by reducing the insect population.

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[1] Slides used by Dr. Berryman were not available for inclusion in the published proceedings.

A VOICE: A point of order. What is the crossway factor?

MR. BERRYMAN: It is just a relative estimate, conceptual estimate of damage. These are not actual figures, they are just in my head.

A VOICE: For what time?

MR. BERRYMAN: Time, in this case, is in a period of maybe 100 years.

The next thing, I think, is to look at what is our status of knowledge on the tussock moth and what important questions have not been answered. Many of these points have been made previously and probably will be reiterated again. First, What do we know about the population dynamics of the tussock moth? We know it is cyclic, occurring periodically in 7-10-year intervals. We know that the collapse of these populations are mainly brought about by virus diseases in about the third year. We know that occasionally tussock moth populations are reduced before they reach epidemic proportions by parasites and predators. But we don't know why these things are occurring. For instance, we don't know the cause of these cyclic outbreaks of the tussock moth, and thus we cannot predict when they will occur nor where they will occur. Do these outbreaks result because of basic instability in the population system, or are they the effects of a disruption of a relatively stable system?

There are other questions that have cropped up in this latest outbreak. The biologists, including myself, believed from past experience that there was a high probability of the virus causing a general decline in the tussock moth population last year. If this decline did not actually occur, and there is some uncertainty on this point, the question is what caused this abnormal situation. These are questions that have to be answered before we can really construct a realistic population model.

In addition to a population model, we require some kind of surveillance device which will act as insurance against the malfunction of our model. All models are oversimplifications of the system and a device is needed to verify the predictions made by the model. Surveillance methods, particularly methods for surveying the tussock moth at very low population levels, are absolutely necessary. Perhaps pheromones will be the answer to this question.

In the area of impact, Wickman and his associates in the Forest Service have made significant contributions. We have a fairly good estimate of the relationship between defoliation in growth lots and mortality. Even more important, we need to know the relationship between defoliation and stress on the tree because we are aware that secondary insects, for example, bark beetles, can contribute up to 80 percent or more of the actual mortality. We need information on the long-term relationship between defoliation and these secondary insects.

For example, the last tussock moth outbreak in northern Idaho collapsed in 1965. This slide shows the buildup of *Scolytus ventralis*, the bark beetle, following that outbreak, and you can see they followed pretty closely after the outbreak.

In the next slide I have analyzed a 40-year period of tussock moth-bark beetle interaction. On top are four outbreaks of the tussock moth, one of which did not occur in the area that I was working in, and below are three population cycles of bark beetles. If the trends shown in this graph hold true, then it appears that we are seeing cycles of bark beetles of increasing amplitude, and the next one may be really catastrophic.

We need to know the relationship between defoliation and direct mortality. That is, what levels of defoliation are going to result in permanent damage to the tree, that is, irreversible stress. And then, of course, as other people have pointed out, we need to know the relationship between defoliation and other factors that are occurring as destructive agents in the forests—for instance, fire.

The next subject to consider is the control methods that can be used in our management prescriptions to deal with the tussock moth problem. First we need to know the long-term and short-term effectiveness of the controls. We have a certain amount of information on chemicals that have been used in the past to control the tussock moth. However, we do not know the selectivity of some of these chemicals. What we need to develop are chemicals that selectively kill tussock moth without harming the other agents that would naturally control the moth (parasites and predators). In the area of biological controls, there are numerous unanswered questions on the effectiveness of various agents that can be used to control tussock moth. How can we speed up virus activity? What is the effectiveness of various strains of the virus? What is the effect of stress on tussock moth, in terms of its susceptibility to viruses. Tests have been carried out using bacteria, but more work is needed to define their control effectiveness. Insect parasites are generally acknowledged as important in stabilizing populations at low levels. What role do parasites have in controlling tussock moth outbreaks? How can we utilize these agents to stop or prevent outbreaks from occurring in the first place? Very little is known about the predators that attack tussock moth. In the area of silvicultural tactics we might consider the manipulation of species composition—age structure, density—to prevent outbreaks. A thought that comes to my mind is, if bark beetles, moving in after tussock moth outbreaks, are responsible for at least 80 percent of the mortality, then perhaps we can save most of this loss by selective logging bark-beetle-infested trees, thereby removing these tree-killing insects until the forests have recovered from the effects of defoliation.

And lastly, and perhaps most difficult, what are the costs involved in this whole system. And, by cost, I mean not monetary costs, necessarily, but the social values involved. First, what is the cost of doing nothing? Certain costs are fairly easily defined, for instance, timber loss. But what is the cost in terms of recreational losses, watershed losses, fish and wildlife losses? We also have to put cost functions on our control elements, particularly in terms of their long- and short-range cost effects. What is the cost in materials, application, etc.? What are the values saved by applying the control? What are the costs incurred to other ecosystem components? If we can come up with these kinds of measurements, in terms of some social or economic value, methods are available for analyzing complex combinations of various strategies and optimizing these strategies to produce minimal costs. I think it is worth making a few comments on the problems of constraints. For instance, we know of legislative constraints that have affected the tussock moth control problem (e.g., the restricted use of DDT). However, in these situations the legislative branch has a responsibility to landowners who are faced with the disaster. Maybe the tussock moth outbreak should be considered a disaster area, and those involved given compensation or special tax relief. There are also constraints on the feasibility of using some control measures (i.e., their effectiveness is not known). This means that we have to put money into scientific research in order to quantify these methods. There are socioeconomic constraints due to the unacceptability of using some control methods. There are ecological constraints that have to be considered; that is, there are methods that can cause irreversible or permanent damage to ecosystems.

In conclusion, it appears to me that what we need on the tussock moth is a tremendous amount of applied and basic research—in comparison with other forest insects, there has been very little research done on this insect—before we can develop viable management systems. I think systems analysis provides a powerful methodology in formulating these management programs. This is basically demonstrated by the success of the space program, which relies heavily on systems analysis. The only way that these objectives can be achieved is through massive infusion of money into research institutions, particularly for research on endemic populations, because the efforts required to study them are enormous in terms of manpower and time. A lot of research also needs to be done on control and cost functions.

There is one thing that strikes me whenever I consider the tussock moth, and that is, perhaps the withdrawal of DDT as a method of controlling it has been a tremendous boon to this particular problem. It is perhaps analogous to the Arab oil problem, in that it has stimulated interest and discussion and an awareness of research needs. Perhaps the money will be forthcoming to develop a solution before the next outbreak occurs. Well, let's see if the interest remains after the present outbreak subsides. This, after all, will be the crucial test. Otherwise, we can only expect panic and confusion in early 1980. Thank you.

DISCUSSION

MR. KORP: Thank you, Dr. Berryman. Are there any questions?

A VOICE: I don't have a question of Dr. Berryman, but I have a question for you.

MR. KORP: All right.

THE VOICE: What is the status of legislation aimed at removal of EPA prerogatives or authority, for example, and what are the prospects of EPA becoming a grantor or coordinator of research and findings?

MR. KORP: The answer to the first question is, the House Committee on Agriculture has indicated that they would like to have a law that gives the U.S. Department of Agriculture control of the use of DDT in forests. As for EPA being a grantor, we are trying to develop a position on where we stand and where we are going.

A VOICE: I have a question for Dr. Berryman. I was wondering if you could tell me how many natural predators there are in the infestation?

DR. BERRYMAN: I think somebody else could answer that question better.

A VOICE: I understand from Dr. Wickman that approximately 20 natural predators have been found in the whole history of this situation. I am wondering how many of those insects are now in this infestation.

DR. BERRYMAN: The question was: There is a complex of natural predators in natural tussock moth populations, and the question is how many of these predators are in the present infestation. I don't think I can answer that; maybe you can, Dick.

MR. MASON: I don't think I can, either. There may be 20 or 30 different parasites, and we have found that many of these occurred in the outbreak, but then we have many new ones. When Dr. Wickman says 20 or 30, he is probably counting all of the parasites that have been determined over many years, and could give you more accurate information on the current outbreak. In this outbreak we are finding some parasites that have been discovered before. We still have a very large amount of them, and we may have some new ones here. Normal parasites are primarily of one or two species.

A VOICE: That is what the research is primarily being done on now.

MR. MASON: We are not looking at the parasites ourselves, but we are quantifying them.

A VOICE: Dr. Berryman, in that same line, once you have a significant outbreak like this, is it reasonable that it can come through parasites?

DR. BERRYMAN: I have not done as much work on tussock moth as some of the people here, but I am an ecologist and I do understand some of the ecological indications. It would be my personal opinion that with low population density—that is, during the endemic period—the parasites could be a very important regulatory force on population. However, once that tussock moth has broken out of this endemic state, the parasites would have an increasingly difficult time overcoming the infestation. I think this is borne out by the evidence. In some instances, parasites have terminated an outbreak before true epidemic conditions arose. Again, I think there is documented evidence on this question. So the possible explanation of tussock moth dynamics is that at an endemic level, synchronized parasites can control the population. But something disrupts this, allowing the population to explode from control by its parasites. And the parasites, under these circumstances, normally do not catch it up. Occasionally they do. This is my interpretation. Some others might have different opinions.

STATUS OF KNOWLEDGE ON THE DOUGLAS FIR TUSSOCK MOTH

Ronald W. Stark
Graduate Dean, Coordinator of Research, and Professor of Forest Entomology
University of Idaho, Moscow, Idaho

INTRODUCTION

MR. KORP: Our next speaker is Mr. Ronald W. Stark, Coordinator of Research, Professor of Forest Entomology, University of Idaho, Moscow, Idaho.

PRESENTATION

Preamble

Almost every report and published paper on the Douglas fir tussock moth begins with some variant of the following statement: "The Douglas-fir tussock moth is one of the most destructive forest pests of western North America." From this, one would expect a corresponding level of scientific activity and, from that activity, a correspondingly large number of scientific published papers. For example, there are in excess of 150 scientific published papers on the western pine beetle, and some 10 or more in various stages of completion at this date. (I am using the term "scientific published papers" to designate papers describing the results of research as opposed to extension bulletins, pest leaflets, detection reports, and the like.) However, a review of the holdings of two forest entomologists and the citations contained in these yields but 26 published papers, not all on research. Examination of these yields some interesting information. There were 1 each in 1921, 1932, and 1949, 5 in the period 1955-58, 6 in the period 1962-67, and 14 in the period 1969 to the present. Allowing suitable time for publication, these spurts of interest correspond closely to outbreaks of the tussock moth.

Looking at subject matter, the papers include seven in what I have termed "survey"; i.e., two detection reports, two on the use of aerial surveys, and three on sampling techniques. There are three papers on impact, including one on decay of top-killed trees and two on growth loss and timber mortality. All three are localized, i.e., for specific areas and time. There are seven general papers summarizing known research which include no new information, one on general biology, and three on "population" studies including histories of outbreaks and reports on the course of current outbreaks. This leaves the grand total of six published research papers on control of "one of the most destructive forest pests in western North America"! These six break down to four on diseases and the disease phenomenon, one on biological control, and one on an insecticide-screening program.

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Since 1921, a total of 31 people were involved in authoring the 26 papers; 15 of these are forest entomologists. Of the 31, 26 authored or co-authored a single publication, 2 non-entomologists were involved with two publications, 2 forest entomologists were involved with two "survey" or extension publications, and only 3 forest entomologists were involved in multiple (more than two) publications—2 from the Forest Service and 1 from a university.

The purpose of this rather lengthy preamble and the introduction of these rather trivial statistics is to make two points leading to a conclusion.

First, interest in the Douglas fir tussock moth has waxed and waned as have the tussock moth populations.

Second, with the exception of the disease program, minimal sustained effort and support has been provided, and this has been restricted to very few individuals.

From the above, we can conclude either that the Douglas fir tussock moth is not the destructive pest we are continually assured it is, or our resources have been inadequate to assign it the high level of priority in research planning the problem deserves. Until proven otherwise, I am prepared to accept the latter conclusion. What then are our needs?

For effective pest management we need *extensive* knowledge in four areas.

Impact

We need an accurate measure of the true damage done by the insect given a particular population level which is applicable throughout its range. This should include not only immediate economic measures of growth loss and timber mortality but a consideration of these in relation to what is left and the recovery rate of the damaged stands. Also included should be other measures of impact, such as the potential hazard from urticating hairs, the effect on values inherent in recreation areas, increased costs of fire protection or actual losses attributing to increased flammability, increased risk or loss from secondary insects, and the like. These should be realistic, not rhetorical, and should permit the decisionmakers to weigh these values against the cost and consequences of control.

Population Dynamics

A thorough knowledge of the population dynamics of the insect is essential in pest management. We must be able to estimate with considerable accuracy and assurance what will happen from generation to generation in terms of insect numbers and the biological damage which will result from those numbers. We should have an understanding of the basic causes of fluctuations in the population—all the insecticides in the world will not prevent outbreaks if the underlying factors causing outbreaks persist. We must have a thorough knowledge of the factors, physical and biological, which regulate tussock moth numbers.

Regulatory Tactics and Strategies

Based upon population knowledge we must have knowledge of those regulatory factors—parasites, predators, disease, forest-stand characters, biological, etc.—which can be manipulated and used as tactics in an overall pest-management strategy. We must also develop insecticides which cause minimal or tolerable harm to the insect ecosystem and the general environment.

Pest Management

Lastly, we must have an approach which integrates the knowledge gained from impact, population dynamics, and regulatory strategies to provide sound information on consequences of action (no action is included), alternatives, and, most important, continuity, which permits reexamination of the consequences of decisions made leading to refinement of the practices made and inclusion of new information as it occurs.

Present Status

Impact. At a Forest Service workshop held at Marana Air Park, Arizona, in February 1972, the problem of impact of forest insects and diseases was studied in depth. Two of the working groups considered the Douglas fir coastal and Engelmann spruce-fir forest types. The general conclusion agreed to by all seven working groups was—

> The Forest Service does not have an adequate system for measuring, evaluating, and predicting insect- and disease-caused impacts on the forest resources of the Nation. Basically, we lack a clear understanding of the concept and practical implications of pest impacts in the total space-time frame of the resource management process. The data base from past work and the present data inputs are incomplete. Specifications for the kind and quality of data needed, criteria for interpretation and evaluation, and bases for value judgments have not been established on a sufficiently broad scale. We have some, but not all the knowledge and methodology needed to fill these voids.

Specifically, for the tussock moth, we have a few excellent, albeit limited, studies. The important conclusions for this group to consider are—

Damage has been essentially the same in treated and untreated areas.

Tree mortality has been restricted to relatively small areas of the outbreak.

Recovery of damaged stands has been rapid.

The studies made represent a few areas and locales, and are largely restricted to growth loss and gross mortality. The Marana Park conclusions hold. We do not have sufficient nor accurate enough data on impact to provide the decisionmaker with conclusive enough evidence for or against regulating action.

Dynamics. The historical aspects of Douglas fir tussock moth outbreaks—at least the visible phase—are well documented. However, next to nothing is known about endemic populations nor the stages leading to an outbreak. Considerably more is known about the decline phase of outbreaks, to the extent that we apparently can predict with reasonable accuracy when a population will collapse from a measure of the incidence of disease within a population. However, well-documented cases are few and this conclusion may be premature—our estimates are obviously not applicable in all situations. We are reasonably sure that there is little to no spread of outbreaks. We know quite a bit about natural enemies, but very little of their role in the dynamics of the host. We know the life cycle, but very little of the detailed biology and practically nothing of the population dynamics.

Regulatory Tactics and Strategies. We are in the process of developing a tactic using natural diseases. Its use is inhibited by lack of mass culturing and delays in registration. We know there exists a communication system involving pheromones, and from other studies we believe use of this knowledge can be a useful tactic in detection and possible control. We know next to nothing about the possibility of manipulating parasites, predators, or forest stands. Our detection methods are inadequate—we know that by the time an outbreak is detected and the machinery of pest control is made operational all outbreaks are in a decline phase. From other studies we have developed an approach to pest management using systems analysis techniques. There could be constructed a research plan which would clearly identify those areas of research in which additional work is needed and eventually yield a control strategy. A simplistic one has been suggested, but it is inoperable at the present time because of our lack of detection techniques.

Research Needs

The above abstract of our present status of knowledge on the Douglas fir tussock moth suggests the needed research areas. I will not dwell on specifics but emphasize that we need research on all aspects of the tussock moth—impact, population dynamics, and regulatory mechanisms—in order to formulate a pest-management system.

The paramount need is to obtain a *commitment*—repeat, a *commitment*—from agencies such as the Forest Service and the Environmental Protection Agency to mount a *sustained* research program of sufficient size which will lead to an acceptable pest-management system for the tussock moth. I emphasize sustained because it is apparent that our research efforts on the tussock moth over the past four decades has been in reaction to outbreaks, interest and support declining almost as rapidly as tussock moth outbreaks.

DISCUSSION

A VOICE: I would like to ask one question of Mr. Stark. Have you made an on-the-spot investigation of the tussock-moth-infested areas?

MR. STARK: No.

A VOICE: There is a need for different areas of research, and I would suggest that there is a basic need for our so-called experts in the various fields to have an on-the-spot, grassroots sighting. If you look out your window, if you come down into Columbia County, I think you might change your mind.

MR. STARK: I thought I was very careful to avoid making a judgment on the current situation. The comments I made about our present status of knowledge were from the published literature. I think I did qualify those remarks.

MR. KORP: I would like to thank all of the speakers this morning for their excellent presentations, and I would like to thank the audience.

Afternoon Session

The transcript of the afternoon proceedings was not available at the time of publication. The manuscripts presented during that session are included; however, there are no questions and answers from the floor.

TECHNICAL PROBLEMS AND RESEARCH NEEDS: WHAT ARE THEY TO THE BUREAU OF SPORT FISHERIES AND WILDLIFE, U.S. DEPARTMENT OF THE INTERIOR?

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Today is a little late to step up research to solve immediate problems of timber losses to the Douglas fir tussock moth, but it is a good time to consider steps to be taken to help solve future problems. A key requirement of the Federal Environmental Pesticide Control Act (Sec. 3(5)) is the demonstration that the test material (insecticide), "will perform its intended function [control pests] without *unreasonable* adverse effects on the environment" (italics mine). Environment is defined as: "the water, air, land and all plants and man and other animals living therein, and the interrelationships which exist among these." I do not know the criteria for determining what is unreasonable, but the broad objectives of future research should be both the protection of the environment and the prevention of pest outbreaks—including, when needed, *acceptable* insecticide treatments for the tussock moth. These objectives are in tune with the system of pest management for the tussock moth and the concept of integrated pest control referred to by several speakers this morning. Integrated control, as I understand it, encompasses silvicultural methods, cultural methods, biological methods, and chemical methods. It depends on knowledge, not only of the population dynamics of tussock moths throughout the endemic and outbreak phases of their cycles, but also of the ecology of other component species of the ecosystem, including fish and wildlife, and their interrelationships with the tussock moth. For example, tussock moths, like most insects, furnish food for vertebrates during some stages of their life cycle. The larvae are apparently not palatable to birds, but the adult moths are eaten by some birds and probably by bats as well, and Dr. Dahlsten told me today that the eggs are eaten by chickadees (it is interesting that the only evidence of tussock moth occurring on our Pike National Forest study area, which I will describe in a moment, was recovered from the beak of a gray-headed junco).

To the U.S. Bureau of Sport Fisheries and Wildlife, the technical problems and research needs are associated not so much with control measures for tussock moths as with the effects of those control measures on the well-being of wildlife and the associated ecosystem. Forest ecosystems are complex interacting associations of plants and animals in a dynamic environment. The characteristics of wildlife—their mobility, varied food and habitat requirements, etc.—make it difficult to keep track of even the most basic parameters: (1) the species, (2) changes in levels of populations, (3) changes in their habitats, and (4) changes in available food resources. And this ignores more subtle effects such as changes in reproductive success or in susceptibility to predation or disease. How to assess the effects of tussock moth control on wildlife—both the direct effects and the indirect ones resulting from changes in other components of the ecosystem—is the major technical problem and corresponding research need. Furthermore, any solution must be economically realistic. The resources available for detection and survey of the tussock moth and its control are several times those available for assessing the environment for any unreasonable adverse effects. The size of the problem may be appreciated if one considers that the environment we must assess contains many complex biotic communities, including aquatic as well as coniferous forest ecosystems. We cannot possibly monitor all elements simultaneously, but I do not believe we can afford to restrict our assessments too narrowly to single species or single communities.

Instead of repeating what previous speakers have said about the needs for cooperative research efforts and listing areas of needed research, I am going to speak further about the Insecticide Evaluation Project (IEP), a functioning cooperative project between the U.S. Forest Service and the U.S. Bureau of Sport Fisheries and Wildlife, mentioned earlier by Dr. Buckman. The IEP is presently headed by Dr. Robert Lyon, at the Forest Service's Pacific Southwest Forest and Range Experiment Station (PSW), and involves the Denver Wildlife Research Center (DWRC) and some additional personnel of the Bureau of Sport Fisheries and Wildlife. This cooperative project, as I understand it, began as a means of implementing the recommendations of the 1963 President's Science Advisory Committee Report. At that time, the late Mr. Lansing Parker of our Bureau and Dr. Warren Benedict of the Forest Service represented the two agencies on the Federal Committee on Pest Control. I would like to credit them with promoting the program and supporting it. With their help, cooperative research was started in 1964 under the existing (October 1960) memorandum of understanding between the Forest Service and the Bureau of Sport Fisheries and Wildlife. The agreement was voluntary and rather an informal one based on areas of mutual interest and an apparent need for cooperative research.

From 1965 through 1967 the IEP was engaged in a crash program to find a replacement for DDT in spruce budworm control, and mexacarbate (Zectran[1]) was the most promising candidate. As a result, the DWRC developed an unusual amount of laboratory and field data on the safety of this material for wildlife. For example, laboratory toxicology tests were run with a number of wildlife species. Among other field tests, the Bureau contracted a grouse study with the Montana Game and Fish Department and conducted short-term field appraisals during four pilot spraying operations in Montana and Idaho. The DWRC studied population trends in songbirds and small mammals on both treated and untreated areas before and after spraying, and other Bureau personnel studied effects on fish and other stream organisms.

In 1967, during the Big Smoky pilot test of mexacarbate, I discussed technical problems and the Government's responsibilities with former IEP project leader Dr. Arthur Moore and Dr. William Upholt as representative of the Federal Committee on Pest Control, and as a result our cooperative effort took a new direction. Generally, operational or experimental insect control programs impose certain restraints on attempts to assess the impact of the insecticide on nontarget organisms. When field tests depend on the presence of suitable target-insect populations (which are not dependable from one year to the next), little time is available for collecting base information about resident species, the study design and application rate are fixed, and the team's resources must be stretched to cover simultaneous appraisals of the treatment's efficacy against the target species and its effects on nontarget species. Eliminating the target insect as a criterion for studying effects of insecticide applications on nontarget birds and mammals was an obvious solution. From 1968 through 1972 we conducted "nontarget only" tests on a study area on the Pike National Forest in Colorado. Instead of several 20- to 40-acre plots within treatment areas of 500 acres or more, we selected 160-acre treatment blocks, each with a single study plot, so that treatments could be randomized and replicated. Instead of trend counts of all birds sighted on the plots, we tried to improve the precision and sensitivity of our censuses by concentrating on the well-being and nesting success of resident breeding pairs. By increasing application rates two to four times the anticipated insect-control rate, we were able to increase the sensitivity of the appraisal and study effects on beneficial insects and on insects as a food resource for birds. We also considered small mammal populations and survival important, but a natural decline in small mammals in the area and decreasing resources for the study caused us to abandon small mammal studies. However, assessments of fish, not originally a part of the study, were later included with the help of operational personnel of the Bureau.

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[1] Reference to trade names does not imply endorsement of commercial products.

Some concessions had to be made to the weather, and some compromises were made in design so that preliminary safety appraisals could be made of several candidate materials. Nevertheless, we felt that this kind of testing greatly improved sensitivity and gave much more useful results than previous studies. Trichlorfon (Dylox) and Bioethanomethrin were two of the seven materials appraised during this period; after their preliminary safety appraisal on the Pike study area, they were considered ready for further field testing, including the tussock moth tests this past summer.

The need for cooperative research has been stressed repeatedly this morning, and I believe the approach the IEP has taken in laboratory testing and field appraisals of candidate forest insecticides for effects on nontarget biota has shown what even modest cooperative efforts can achieve. We do need the resources to replicate treatments and, because of turnover in personnel, more formal agreements and better coordination of cooperative efforts. There is a clear need for better planning and stronger commitments if we are to have adequate funding to continue doing the job.

I strongly feel that fish and wildlife must be considered in any program for developing forest insect-control strategies. Some species are undoubtedly important predators of target insects and therefore allies of the forester. More important, wild vertebrates have value in themselves and are certainly indicators of environmental quality. Therefore, the well-being of fish and wildlife should be a consideration in any integrated pest-control strategy and a basic criterion for judging unreasonable adverse effects on the environment.

DOUGLAS FIR TUSSOCK MOTH RESEARCH NEEDS: A POSITION PAPER

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Someone has remarked, with reference to the factors which have precipitated this seminar today, that "It has never been a tussock moth issue; it has always been a DDT issue." The accuracy of that statement is obvious, and it necessitates the conclusion that research needs cannot be considered appropriately until the present atmosphere has been cleared by recognizing national and agency policy. At the national level, that policy is that DDT will be used only in the case of a national emergency; at the agency level the use of DDT was phased out in the late 1960's.

The fact that DDT has been allowed to dominate the issue has had a number of pernicious, oppressive results. It has stifled communication at the agency level and has restricted agency-public interest group communication. It has led to distortions of the extent of the existing and threatened damage. It has obscured the reality of pest population collapse in many areas. It has reduced the probability that decisions will be made on the basis of scientific evidence and increased the probability that policy will be determined primarily by emotional and political means.

But most importantly, the intrusion of DDT has had an adverse influence on research and researchers. I am convinced that it has been responsible for the temporary suppression or distortion of data; certainly it has resulted in the tardiness of data on several occasions. There is evidence that it has threatened the security of some workers of both persuasions. The free discussion and exchange of data have been discouraged, and the judgments of researchers sometimes have been ignored. Unless these stigmata are removed—and I have suggested a means of removal—we cannot hope to proceed with a research program in an atmosphere of academic freedom and scientific objectivity.

With regard to the research needs themselves, I think we should temper our priorities with the knowledge that the Douglas fir tussock moth is a native insect of transient and irregular importance. While the extent of defoliation in the declining 1973 infestation may have been historically important, there are certainly other insects which, in the long run, are actually or potentially more important.

I have attempted to arrange the list of research needs in such a way that it follows the normal pattern of events in an infestation cycle:

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Endemic Populations

Apparently there have been no extensive studies of endemic populations. I am not sure that a truly endemic population has been identified. We speculate that endemic populations are controlled by parasites and predators; we know that epidemic populations are regularly terminated by the virus disease. It seems probable that a population dynamics approach at the endemic level would be most productive.

What triggers the periodic release of endemic populations? We tend to speculate that climate somehow influences release, but climate can be only a proximate factor; we need to know the ultimate factor or factors governing release.

Detection of Incipient Outbreaks

There has been much talk about and support for research designed to identify and synthesize tussock moth pheromones, largely for the purpose of perfecting an "early warning system." While these efforts certainly should be encouraged, it should also be realized that pheromones, for all their current popularity, are not alone likely to solve the problem of detection. Research should also focus on improving other techniques of detection, including the beating plots and the education of onsite personnel.

A sampling system for predicting incipient outbreaks has been developed. Unfortunately it was not widely applied in this infestation when elements of it were first detected in 1971, nor, apparently, was it employed in comparable areas in 1972. Instead, it has been used, essentially unchanged, in an attempt to estimate damage in 1974. The sampling procedure was not designed for that purpose; research should evaluate the system's utility in an epidemic situation before it is actually employed to determine projected control strategy.

Released Populations

Ideally, control should be directed at populations during the release phase of an outbreak before the majority of damage has been done. Although it appears that most populations in the current outbreak are beyond that point, research with synthetic and microbial insecticides should focus on the release phase. Furthermore, this research should consider primarily the possibility of providing protection for the small, private owner, who always suffers most from the effects of this pest.

No artificial control, whether attempted with synthetic organic pesticides or microbials, will be without disruptive ecosystemic effects. Research should bear this in mind, especially with regard to naturally occurring parasites and predators.

The efficacy of any new material must be carefully and properly documented in the field. This means that control plots and adequate sampling design must be employed. It is sad commentary that after over 20 years of DDT use against tussock moths, we were left with no adequate data concerning the efficacy of the poison under field conditions. In some cases this deficiency was the product of oversight or poor planning, but in most cases it resulted from the catastrophic influence of the natural virus which decimated populations on both control and experimental plots. By focusing our attention with regard to new materials on populations in the release phase, this interference might be minimized.

Investigations of the roles of natural enemies should be accelerated during the release phase. What population characteristics during this phase can give new clues concerning the mechanisms of release? What can we predict for the following year?

Within the pest population itself, it will be important in the release year to examine parameters of fecundity, dispersal, and possible genetic factors that may express themselves.

The ecology and economics of defoliation and tree mortality must be examined in depth. Keying from the observation that Douglas fir and true firs coexisted with this pest aboriginally, we must consider the possibility that a symbiotic relationship prevailed prior to the advent of modern forest practices. That relationship, if revealed, might be turned to modern advantage. The economics of tree mortality are especially important in mixed stands where salvage logging is used as a management tool.

Declining Populations

In the third year, which is most commonly the year of collapse for the pest population, studies begun earlier should be continued, but special attention should be given to the epidemiology of the virus disease to include interactions with other natural enemies. The precise mechanisms of the decline, particularly at the periphery of a population, should be investigated. This would also be an ideal time to refine our understanding of the timing of eclosion. Secondary invaders, like bark beetles, would come under special scrutiny at this time. The role of parasites and predators, which is characteristically most significant during this phase, should be given particular emphasis.

Viewing the research picture as a whole, two deficiencies are particularly obvious. Parasites and predators have been investigated only superficially. While we have partial information on the species involved in various infestations, we know virtually nothing about life histories, including alternate hosts. The possibility of classic or near-classic biological control seems as remote with this species as it does with any native forest insect, but variations on that theme, involving environmental manipulations of understory or the introduction of parasites absent in one area from another locality, remain possibilities. None of this work can be attempted until the life histories of the natural enemies are understood. Second, survey and predictive techniques must be refined. The techniques currently in use are simply not adequate to the task and will not support a proposed spray program.

The old-to-new egg-mass ratio system apparently dates from a 1947 infestation. To my knowledge its predictive power has never been tested quantitatively. It also suffers from some inherent biological biases. It seems possible that existing data might support it, but until the evaluation of the technique goes beyond the anecdotal phase, it cannot be considered useful.

The system that relates density of egg masses to pest density after hatching is the most sophisticated system, but it was designed for first instar larvae in incipient outbreaks, not for egg masses in older infestations. Certainly an adaptation of it would be useful, but, again, I am aware of no test that has demonstrated its efficiency in this situation; as practiced by the agencies currently surveying egg masses, it is superficial in that it fails to accommodate, first, the irregular distribution of host trees and, second, the irregular distribution of the pest within the host tree pattern. The "time plot" approach, also being used this year, and apparently for the first time, seems inherently plagued with a large number of unmanageable variables. It may be useful for determining presence or absence, but it is not a quantitative technique.

These criticisms are offered constructively and with full and personal knowledge of the logistic and economic barriers involved in mounting a comprehensive population survey. The fact remains, however, that this area should be given very high research priority.

As we discuss research needs today, we should bear in mind that a large volume of good work has been completed and published; other work is in progress or planned. We should urge that the work accomplished be recognized and respected, and we should thank the small number of researchers who have produced the work, often on minuscule budgets and with extreme effort.

Finally, I would like to suggest that some potential research in the current situation is research that need not be repeated or that we should consider of very low priority.

Monitoring programs have often been used as partial justification of spray programs involving DDT. There is an innuendo present in their planning to the effect that the monitoring program will somehow prevent damage. This is, of course, not the case, especially with DDT. The programs are always hastily arranged and underfunded, as in the case of the Burns Project in 1965 and the Willipa Bay Project in 1963. This is not to say that such programs should have been discouraged during the heyday of DDT, but monitoring programs should not be bones thrown to conservationists.

And we would benefit very little from additional information regarding the effects of DDT and DDE on nontarget organisms. The literature on that subject is voluminous, and those effects are now known to be largely deleterious. The association of eggshell thinning in birds with *p,p′* DDE is one of the best known of ecological phenomena. It has been shown so many times in both wild and captive species that at least one journal has complained about receiving "Further verifications of phenomena already demonstrated."

We have considerable information about the Douglas fir tussock moth now. If we are to move forward with research, if this seminar is to bear fruit, we must all lock arms and agree to clear the air of the poisons that obscure objectivity and inhibit cooperation by imposing the constraints of politics and emotionalism.

PREVENTING DOUGLAS FIR TUSSOCK MOTH OUTBREAKS: A VIEW FROM THE PESTICIDE INDUSTRY

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I appreciate the opportunity to participate in this discussion of the current Douglas fir tussock moth outbreak that has wreaked such havoc in the timberlands of eastern Oregon and Washington. I hope the views presented here are representative of those generally held by my industry.

First, I want to assure you that the pesticide industry welcomes the opportunity to work with any organization in finding solutions to problems such as this. I believe the major body of knowledge on pesticidal chemicals, formulation technology, and perhaps application techniques in the country resides within our industry. I do not believe I am being overly egotistical in saying that so far as the insecticides themselves and the formulation know-how to make them work, the best source of information is within our industry. We have developed the technology base on application techniques in order to assure that our chemicals are properly used to obtain maximum effectiveness, and with the least hazard to man and his environment. In addition to our own engineering efforts, many of our member companies give financial support to new engineering technology. We also have thousands of scientists and technicians throughout the world who are in constant contact with work that is underway wherever pesticides are being used and whose duty it is to report any new developments as they are taking place. Thus, there is a large body of knowledge and experience that could be brought to bear on problems such as this, provided we are given adequate opportunity to participate.

What I am suggesting is that the pesticide industry be considered a member of the team in forestry, as we have been in the agricultural and public health fields. Despite some criticisms, this teamwork has solved many, if not most, of the more serious agricultural and public health pest problems that have occurred in this country. Enough so, I might add, that the rest of the world is trying desperately to emulate us in this area.

I would like to make a couple of things clear in the beginning. Although I am representing the National Agricultural Chemical Association (NACA) at this seminar, the views I express here are my own and have not been discussed with NACA or any of its member companies. Second, I have always been a strong supporter of DDT. I believe the discovery of the insecticidal activity of this compound is probably the greatest discovery of the past 50 years. I am certain it has done more good for more people with the least amount of

harm of any recent discovery. Having said that, however, I must also say that I am and have always been opposed to the use of DDT for control of forest defoliators *if* there were selective insecticides that could be used in its place. Since the early 1950's, I have attempted to find alternatives to its use in forestry. Not for any of the reasons generally given by the opponents of DDT, but because it was too broad spectrum, too persistent, and as a result has too severe an impact on beneficial insects.

The Current Outbreak as Seen from the Outside

The extensive damage caused by the current tussock moth outbreak appears to be a result of a number of things occurring more or less simultaneously which prevented the Forest Service from taking decisive action in time to prevent some very substantial losses, not only of timber but of wildlife and recreational values. As I understand, the outbreak was first detected in 1971. However, it was not of sufficient magnitude at that time to justify corrective measures. I am sure had the Service gone through the laborious procedure of filing an environmental impact statement to justify a control program, had it reviewed by the Region and passed on to Washington for review and approval, it almost certainly would have been turned down. In addition, the only insecticide with which the Forest Service had had any measure of success against the tussock moth was no longer available to them. In 1972, when it became obvious that they had a major outbreak on their hands, it was too late to prepare the environmental impact statements, have them reviewed and approved, appeal for release of DDT and obtain it if approved, arrange all of the transport and application equipment, and apply the pesticide in time to have any impact on losses. When the magnitude of the outbreak was realized, the Forest Service began making contingency plans for a large-scale control program for 1973. They drew up the necessary environmental impact statements and made plans and arrangements for equipment and personnel to carry out the control program. I understand that several requests were made that EPA allow them to use DDT on an emergency basis. When the initial request was turned down, it was appealed and was again turned down. All of this was done despite the fact that most previous tussock moth outbreaks that have been studied have, in fact, collapsed during the second year of the blowup. Thus, it appears to me that the Forest Service did all that it was possible for them to do within the constraints that have been put around them.

This would seem to make the Environmental Protection Agency the villain, and, in fact, that is what I read in some of the press reports that have come to my attention. However, I think we might examine that a bit. We should all recognize that the function of EPA is to administer the laws as they have been passed by the Congress. While the law does allow some flexibility, one of the primary reasons for its passage was to eliminate just such usage as that proposed here. While I strongly question the validity or the scientific objectivity of the data used to support the ban on DDT, I believe it would be equally poor policy to use the same tactics to effect its return. I have reviewed a number of the reports that have been written on the control programs using DDT on past outbreaks. Since they have been applied almost without exception to outbreaks in the decline phase, the picture regarding efficacy of DDT is rather clouded. In view of this and in view of the public fears—unjustified, I believe, but nevertheless real—of DDT, plus the fact that past outbreaks have almost invariably collapsed in the third year, I am afraid I would have been equally reluctant to release it for this use. Hindsight indicates the decision was perhaps wrong. However, if we could all see forward as well as backward, we would avoid practically all of our problems.

Now, if the Forest Service is not to blame and EPA is not to blame, then where does the blame lie? I would like to suggest that this problem, and perhaps many more serious ones that we will face in the near future, is a result of a great deal of legislation passed on the basis of emotionalism rather than scientific judgment. EPA, of course, has the unenviable task of administering this legislation.

In any event, following the rejection of their appeal, the Forest Service attempted to salvage something from the outbreak. They used all of the Zectran that was permitted, and in addition, applied three other compounds—Dylox, Sevin, and Bioethanomethrin—that might have promise. The conclusions reached, as of the last report that I have, are that with the possible exception of Sevin, none of the materials performed satisfactorily. However, as I analyze the reports, I interpret the results quite differently. It appears to me that three—Sevin, Dylox, and Zectran—performed in an outstanding fashion in view of the amount of material that reached the insects. With Zectran at 0.30 pound per acre, only 6 to 19 percent of the spray, or an average of 0.6 of an ounce, reached the ground. This provided a range of 76 to 93 percent control of the larvae. Dylox, at 2 pounds per acre and an average deposit of 9 ounces, gave 81 to 98 percent mortality. Sevin, at 1 pound per acre with an average of 1.5 ounces deposited, gave 79 to 90 percent control.

Now, compare this with the proposed use of three-fourths of a pound of DDT per acre. I cannot help but doubt very seriously that DDT would have done any better, if as well, as others. It is most unfortunate that DDT was not included in these tests. As a scientist I cannot understand this. In any event, it seems very obvious that the failure was not a failure of the insecticides, but rather a failure of application. From the data that I have seen, it would appear to me that there are at least three potential alternatives to the use of DDT for Douglas fir tussock moth control. The problem seems to be getting an adequate application, and this is not a function of the insecticide. I am sure that any of our industries would be happy to give any assistance we could to help insure proper application of the insecticides. I hope you will not infer from this that I feel any of these should be substituted for DDT at this point. I do not, but I do feel a substitute should be found as rapidly as possible.

Zectran—an Example of One Effort to Find a Suitable Alternative to DDT

I indicated in my opening remarks that the pesticide industry welcomes the opportunity to help solve any of the forestry problems where we feel we might be helpful. Now, I would like to give you a concrete example of how far we are sometimes willing to go to help solve such problems.

Throughout the history of this outbreak, there has been a lot of discussion about Zectran insecticide. Perhaps you may be interested in some of the history behind it. The Dow Chemical Company discovered this compound and its insecticidal activity in 1952. Very extensive research was conducted on it through the 1950's, pretty well delineating its activity against various agricultural and horticultural pests. Zectran was found to be highly active against many lepidopterous insects and against slugs and snails but, with minor exceptions, not very active against other insect groups. It was also discovered that it was a very expensive compound to make. Despite this, Dow began marketing Zectran in the ornamental field, hoping that a less expensive process could be found. Even with the expenditure of several man-years of effort, we were unable to accomplish this and could see no way that Zectran could compete in price with the older compounds such as DDT even though it was several times more active to many foliage-feeding insects. In late 1963, a decision was made not to invest more money in the product. However, shortly after this decision was made, a delegation from the Forest Pest Control group of the Forest Service asked for a meeting in Midland, Michigan, to discuss their findings on Zectran. They indicated at that meeting that Zectran appeared to offer the most promise as an ecologically acceptable substitute for DDT for control of forest tree defoliators. Their data were impressive, indicating toxicity ranges from 2 times to 185 times that of DDT for most of the more serious defoliating insects. The data I have from the Insecticide Evaluation Project (IEP) indicate Zectran is 2 to 3.2 times as active against Douglas fir tussock moth as DDT. The toxicity picture on fish, mammals, and birds appears to be very favorable. Subsequent studies have confirmed this. Dow was asked to hold Zectran for them at least until they had time to complete their studies. Our management agreed to this. Various field studies were run from 1964 through 1968. Results were generally good to excellent at very low dosage rates, with the exception of a couple of studies that were run to perfect some highly advanced application technology. Finally in 1968, after it appeared the program would probably never get off the ground, Dow's management decided to close the books on it once and for all. At that time Dow offered to license the Government, at no cost, to make Zectran or have it made by anyone they could find to make it. They would supply all of their data to them or to any third party and even loan them chemists, again at no cost, to help get it started. Dow was asked to help them find a manufacturer. Many months were spent in discussions with, I believe, every company in the United States and a number of foreign companies who had a knowledge of carbamate chemistry in an effort to find someone to produce Zectran for the Forest Service. These discussions continued through 1969, but no one else would undertake the project. When this was unsuccessful, Dow finally agreed to make the compound for them. However, the Forest Service was told that the cost would be highly volume dependent and would be somewhere between $10 and $64 per pound, depending on their requirements. At that time the best estimates of the probable use rate of 70,000 to 100,000 pounds annually indicated a cost of about $18 per pound. When the Forest Service still did not back away, Dow assembled a new team of synthesis chemists to take another look at possible alternate routes of synthesis. As a result of this effort, a way was found to reduce the cost appreciably over the initial estimates. Finally, in 1970, the Forest Service signed a contract for 200,000 pounds. A plant was built to produce the compound. The plant operated, I believe, a total of 8 months and has now been closed for 2 years.

Currently, Dow has invested over $6 million in the project since their initial agreement with the Forest Service, and total sales, including those for the ornamental trade, amount to slightly over $2 million. Thus, there is a negative balance of over $4 million that has been invested in an effort to provide a suitable substitute for DDT. I point this out as an indication that the pesticide industry is dedicated to helping solve your problems and doing it in an ecologically acceptable fashion.

Up to this point, I have generally dwelt on the past when the reason for this meeting is to discuss the future. In this vein, I would like to briefly outline what I as an outsider, but nevertheless one who has considerable experience in forest and general entomology, view as major problems in controlling forest tree defoliators and preventing the losses such as those experienced here. Please note that I have and will continue to confine my comments specifically to defoliators.

1. Forest entomologists view chemical control as the very last resort, to be used only when there is a good likelihood that extremely high timber losses are going to occur. There is considerable justification for this. It is the way we were all taught in school. Foresters in

general and forest entomologists in particular are by training ecologists. We believe the natural control agents are the primary factors in keeping destructive pests under control and we try to manipulate the forest in such a way that we maximize the effectiveness of these agents. In addition, the almost total reliance on DDT for control of defoliators has strengthened the belief that when chemicals must be used, we can expect some serious, deleterious side effects. If I recall correctly, the last time DDT was used on the tussock moth there was a serious mite outbreak in the treated area. In addition, the common belief among forest entomologists that once you start spraying you have to continue spraying is not without justification. I know of one operation that has been going on for 24 years with controls ranging from a low of 79 percent to a high of 99+ percent. Yet today, that infestation is larger than it has ever been. I suggest that this does not have to be the case. When *selective* insecticides have been used, I know of no instance where a secondary problem has developed.

2. As a result of the economics in forestry, forest entomologists continually look for the cheapest compounds available. However, due to the economics of producing pesticides, this invariably means the broad-spectrum insecticides that kill all types of insects—exactly opposite from what I believe should be used in forestry. I would suggest the major concern should be to find the insecticide that does the job best with the fewest secondary problems. After all, the cost of the chemical is the smallest part of the total cost.

3. The constraints placed on forestry personnel in dealing with defoliator outbreaks prevent them from taking decisive action in time to prevent large losses and makes control efforts far more difficult and costly. By the time all of the paperwork is completed and approvals obtained, the chemicals, equipment, and personnel assembled, it is a slow-moving outbreak indeed that has not already done serious damage. With some defoliators, such as spruce budworm, you can get away with that, but certainly, as demonstrated here, not with an explosive insect like Douglas fir tussock moth. I can see no more justification for environmental impact statements in dealing with explosive insect outbreaks than for making fire crews do the same thing.

4. The restrictions on the Forest Service against stockpiling materials makes it difficult to respond quickly to emergency situations. This is ridiculous and like saying that fire crews cannot stockpile materials for fighting fires. I can see no justification for such a ruling. We have entrusted the care and management of hundreds of millions of acres of one of our most valuable natural resources to the Forest Service. Certainly, we can trust them to use the tools they need wisely.

5. Inadequate survey procedures. With many forest insects incipient outbreaks today are relatively easy to detect. With insects such as the Douglas fir tussock moth, this is not the case. Outbreaks occur sporadically, and during low periods the insect is almost impossible to find. However, a similar system to that used in detecting gypsy moth should be effective. I understand this work is well underway. When incipient outbreaks are detected, they should be held in check with chemical controls at least until such time as the use of disease organisms has been perfected. Again, I believe it is most important that selective insecticides be used to prevent damage to the parasite and predator complex.

6. Develop alternative materials. With the current restraints on the pesticide industry, I would like to see the forest entomologist develop alternate compounds which might be used and used with confidence in the event their first choice is not available. There are quite a number of potential choices of selective insecticides that might be used so long as the

forest entomologist or forest manager does not get hung up on trying to save a few pennies per acre.

7. Develop application techniques that can be relied on to work—not so much from the standpoint of saving money, but rather to get the job done and get it done efficiently and effectively.

8. Make use of the knowledge and technology that is available from the pesticide industry, equipment manufacturers, and other public and private organizations.

I am convinced if we do these things, we can avoid catastrophes and near catastrophes such as the current problem with Douglas fir tussock moth.

THE TECHNICAL PROBLEMS AND RESEARCH NEEDS: WHAT ARE THEY TO INDUSTRY?

Dr. Philip A. Grau
Agricultural Chemicals Research and Development
Agricultural and Veterinary Products Division
Abbott Laboratories, Fresno, California

Perhaps the best way for me to address the subject matter of this seminar from the viewpoint of the industry in general, and Abbott Laboratories specifically, is to begin with a brief sketch of our involvement in the control of forest insect pests.

For the past several years Abbott has been involved in the research and development of our biological insecticide Dipel, a preparation of *Bacillus thuringiensis* highly active against several lepidopterous defoliators of forest trees. Much of the original work was in cooperation with the U.S. Forest Service and several State forest agencies in the northeastern United States against the gypsy moth. While there is a continuing effort to expand our knowledge of gypsy moth control, ample data were generated from this research to enable Dipel to be registered for use by ground or aerial application. *Bacillus thuringiensis* has also been registered on other defoliators of deciduous forest hosts in recent years, including elm spanworm, spring and fall cankerworm, and tent caterpillar.

Obviously, the control of defoliators infesting coniferous forests presents different conditions from those associated with the broadleaf hosts. The current generation of *Bacillus thuringiensis* preparations (that is, those produced since about 1970 from strains with greater insecticidal activity than previous products) has only recently been investigated for efficacy against lepidopterous defoliators of conifers. Certain work in Canada has indicated real promise for the control of defoliation by the spruce budworm. Here in the West, experimental field trials employing aerial application of Dipel to fir forests in British Columbia during the past summer resulted in encouragement that populations of false hemlock looper can be effectively controlled and that foliage can be saved. A field experiment conducted by the U.S. Forest Service against the pine butterfly in the Bitterroot National Forest of western Montana showed that, when Dipel was applied at 1.0 pound per acre by helicopter, the population was reduced by 92 percent in 12 days when compared to untreated plots.

Concerning our subject of interest today, the Douglas fir tussock moth, Abbott Laboratories gained research data and a considerable amount of experience with our *Bacillus thuringiensis* product from several cooperative studies which we conducted on private or State forests in Oregon and Washington during 1973. This work was conducted under an experimental registration issued by the EPA for this use of Dipel. A most encouraging trial was the thorough field experiment conducted in northeastern Oregon during the past

summer by the U.S. Forest Service research team from the Pacific Northwest Forest and Range Experiment Station at Corvallis. As their numerical data have not yet been published, I will not be specific, but I know many of you have read or heard that with one of the two additives tested as a tank mix with *Bacillus thuringiensis*, the biological insecticide was highly effective in reducing tussock moth larval numbers which resulted in significant foliage protection.

By prefacing the remainder of my comments with this description of the status of *Bacillus thuringiensis* as a forest defoliator control agent, I have attempted to point out that there just might be a biological (microbial) insecticide suitable for Douglas fir tussock moth control in the not-too-distant future if the remaining necessary research can be supported to the degree that has been seen with certain of the chemical candidates.

Here we have a material that is in harmony with our environmental concerns, since it is produced from a bacterium which occurs naturally at low levels in the environment; controls only the larvae of certain butterflies and moths at standard use levels, leaving predacious and parasitic insects, other beneficials, birds, fish, and mammals unaffected; and will not accumulate in the food chain. Additionally, it has properties we consider necessary for an acceptable insecticide including:

1. A mode of action, referred to as a stomach poison, which soon after it is ingested, causes a cessation of larval feeding resulting in the curtailment of further defoliation
2. Good residual activity, lasting from several days to approximately 2 weeks, depending upon weathering factors
3. No major mixing or handling problems in the field
4. Current availability, since it is a proven method of control for many agricultural insect pests
5. The aforementioned safety to nontarget species and exempt from the requirement of a tolerance for residues on 31 edible crops

So, while I believe we could be close to knowing whether or not *Bacillus thuringiensis* can be considered one of the choices for effective tussock moth control, we are not yet able to make that decision. Efficacy has been shown from carefully controlled experimental field plots utilizing one rate, one set of tank-mix components, and one spray volume. It is necessary to continue on a logical course of field development by testing these conditions in a pilot study.

In general, the technical problems that must be solved for the possibility of eventual operational use of *Bacillus thuringiensis* as a forest insect control agent are not too unlike those of any candidate insecticide. All parameters must be adequately researched to insure that the required physical and biological conditions necessary to assure efficacy are maintained at each developmental level, up to the point of operational use. One problem area that is not faced in a developmental program with *Bacillus thuringiensis* is the need for lengthy studies documenting the environmental impact. The product has a history of commercial use and a track record that supports the claims of safety to the environment. An area where *Bacillus thuringiensis* suffers a technical disadvantage, however, is that of the apparent lack of awareness of this potentially valuable tool for forest insect control exhibited by both the public and scientific community, except of course for those few individuals intimately involved in its development or use. Many of those who are aware of it seem to consider it an academic curiosity that is not available as a practical tool in large-scale control programs. Naturally, this attitude is detrimental and makes it difficult for certain research groups within governmental agencies—namely, the Federal and State forestry groups—to obtain the necessary support for projects dealing with biological insecticides. I have even seen statements in U.S. Forest Service documents and heard statements at meetings where *Bacillus thuringiensis* and the insect viruses are discussed together as not being commercially available. This is currently true of the tussock moth virus, but is certainly untrue for *Bacillus thuringiensis*. I would like to set the record straight by making it clear that Abbott Laboratories' preparation of *Bacillus thuringiensis* used in the experimental programs against tussock moth is the very same Dipel that is used domestically and internationally on agricultural crops. Indeed, we have already seen commercial use against the gypsy moth for 2 years in the northeastern United States and against gypsy moth and several other defoliators of European forests.

The most pressing research need relating to *Bacillus thuringiensis* control of Douglas fir tussock moth, as we view it, is to conduct a pilot control study in 1974, as I mentioned earlier. Such a program should be conducted in nothing less than the most scientifically sound manner known. Of near equal importance is the need for concurrent exploration of several variables at the experimental plot level. Such research should be aimed at defining the optimum volume of delivered spray; determining which, if any, spray additives are beneficial; making an accurate assessment of residual effectiveness; and expanding our knowledge of treatment timing and number of applications required. We need a better understanding of the effect of *Bacillus thuringiensis* against populations at different stages of an outbreak cycle. All *Bacillus thuringiensis* tests in 1973 received only one application in contrast to most of the chemical insecticides which were applied twice. Can the level of effectiveness shown with *Bacillus thuringiensis* in 1973 be achieved consistently with a single application? We need to find out, and 1974 is the time to do it.

In addition to my foregoing comments, our position relating to solving current and future Douglas fir tussock moth problems is that it is imperative that adequate support be available during this current outbreak to enable a thorough exploration of potential control candidates so that a new set of recommendations will result for 1975 and beyond. We must remember that in future years the environmental impact of pesticides may be of even greater concern than it is today. Whether or not DDT will be used against tussock moth in 1974, there exists no rational reason to neglect the research and development of alternatives. There is a particular need for materials that can be used on forests receiving high recreational use and on watershed lands. We feel that *Bacillus thuringiensis* should receive its fair share of the monies allocated to pursue such alternatives, as it appears to be a viable candidate for Douglas fir tussock moth control.

TUSSOCK MOTH VIRUS PRODUCTION

Edward B. Westall
Vice President, Lakeview Operations
Nutrilite Products, Inc.
Buena Park, California

Mr. Westall's presentation was not transcribed. Chart materials used in the presentation are included in the following pages.

Table 1.—Tussock moth virus-production time from eggs to final preparation

Step	Description	Time
1	Egg masses collected from the field	
2	Egg masses stored in refrigerator, minimum storage period	Approximately 3 months
3	Egg masses broken and sterilized, incubation period	10-14 days
4	Larval growth for virus infection (weight 250-350 mg), duration period	21 days
5	Incubation period after infection	14 days
6	Harvesting, freezedrying, and packaging duration	2 days
	Total time required from step 3 through step 6	51 days

Table 2.—Problems involved in tussock moth virus production
[Percent larvae infected = 22.1]

Egg viability and larval death due to natural causes				
Number of eggs received	Number of eggs hatched	Number of larvae dead by natural virus	Miscellaneous death	Number of larvae survived to infection
80,000	48,802	40,000	4,252	4,550
93,000	64,155	48,000	3,530	12,625
65,000	59,208	–	3,601	55,607
88,000	–	–	–	–
328,000	172,165	88,000	11,383	72,782

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Table 3.—Tussock moth virus production: safety tests conducted

Test No.	Test description
1	Determination of the infectivity titer and detection of unwanted pathogens, by assay, in living larvae
2	Detection of free virions and toxic substances, by assay, in living larvae
3	Detection and enumeration of bacterial contaminants
4	Detection of toxic substances or pathogenic micro-organisms, by inoculation of warm-blooded vertebrates
5	Serological test

Table 4.—Government contracts completed by Nutrilite Products, Inc.

No.	Description
1	Investigations designed to develop new or improved methods to rear on semiartificial media the beet armyworm and the yellowstriped armyworm for nuclear polyhedrosis virus production: 1966-69
2	Experiments to select virulent mutants from populations of the nuclear polyhedrosis virus disease of the corn earworm: 1966-1967
3	Douglas fir tussock moth virus-production contract: 1966-1967
4	Douglas fir tussock moth virus-production contract—10,000 acres: 1972-1973

Table 5.—Tussock moth virus-production time requirements
[Dosage application per acre = 1 X 10^{11} PIB]

Eggs	PIB	Time	Acres
4.5 X 10^6	1.25 X 10^{15}	6 months	12,500
11.25 X 10^6	3.125 X 10^{15}	1 year	31,250
22.5 X 10^6	6.25 X 10^{15}	2 years	62,500
33.75 X 10^6	9.375 X 10^{15}	2½ years	93,750
45 X 10^6	12.5 X 10^{15}	3 years	125,000
90 X 10^6	25 X 10^{15}	3½ years	250,000
135 X 10^6	37.5 X 10^{15}	4 years	375,000
225 X 10^6	62.5 X 10^{15}	4½ years	625,000

TUSSOCK MOTH VIRUS CONTROL REPORT

Lot No.____________________

Sample Received____________________

PIB Count:

Date	PIB/gm × 10^8

Average____________________

Mouse Injection Test:

Passed:______ Failed:______

Mouse Feeding Test:

Passed:______ Failed:______

Serological Test:

Hemagglutination Titer__________

Inmunodiffusion Test__________

Reported by:____________________

Released by:____________________

Date of Report____________________

Bioassay__________ LD_{50}__________

Bacterial Contaminants:

a) Aerobic Plate Count

Date	Count

b) Anaerobic & Microaerophilic (Brewer Agar)

Date	Count

c) Gram Negative Count (EMB Agar)

Date	Count

Typhoid Negative____________________

Paratyphoid Negative____________________

Dysentery Negative____________________

d) Count MacConkey Agar

Date	Count

e) E. Coli Negative____________________

Staph Negative____________________

Pseudomonas A Negative____________________

Shigella Negative____________________

Salmonella Negative____________________

FOREST INDUSTRY'S VIEWS REGARDING TUSSOCK MOTH

William H. Lawrence, Ph. D.
Forestry Research Center
Weyerhaeuser Company

Mr. Chairman, I want to express the appreciation of the National Forest Products Association (NFPA) for the invitation to participate in this important seminar and present the forest industry's views regarding tussock moth research needs.

Although EPA is correct in identifying me as a professionally trained forest wildlife biologist with Weyerhaeuser Company, I am here today representing NFPA in my capacity as chairman of the forest chemicals task group.

Though it is tempting to present to this symposium an "official" industry assessment of the impact of tussock moth and debate the statements of certain environmental extremists (and I have been urged by several colleagues to do so), I will abide by the seminar's guidelines and confine my comments to technical considerations attendant to controlling tussock moth and our perceptions as to research needs.

I will deal with short-term or immediate considerations first, then will present several recommendations regarding action steps with longer range objectives in mind.

Short-Term Options

The current tussock moth outbreak warrants prompt, positive action to contain it. Let us not debate whether the tussock moth is or is not a forest insect pest of major importance because of the periodicity of its outbreaks. But rather, we should view the current outbreak as having an adverse impact of major importance on our timber resources. We do, in fact, have an a priori demonstration that the past course of action has failed. We have relied heavily on the advent of a buildup in nature of a "virus" epidemic to control tussock moth. This has not taken place as we complete the third year of this insect outbreak. From reading the EPA news release announcing this seminar, it is evident that we lack, in an operational sense, effective second-generation insecticide replacements for DDT. Here we are on the threshold of a new year, the fourth year of tussock moth, no better off than we were at the start of 1973. We all have specific publics to serve, and public dissatisfaction is running high in many quarters, as the Congress is rapidly learning.

Before reviewing our short-term action steps, a brief review of certain characteristics of the tussock moth is in order. As I understand it, this particular tussock moth episode is

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characterized by a series of *local* yet spontaneously occurring outbreaks, some of which have coalesced into areas of many thousands of acres in extent. Other foci remain as "outliers" of varying sizes, all with the potential of increasing in size during 1974. Some persons may view this outbreak in its entirety as a single phenomenon, whereas, biologically speaking, there is a series of concurrent outbreaks in progress not necessarily "in tune," if you will, with one another. The spread of virus amongst caterpillars depends on direct contact with infected individuals or on noninfected caterpillars traveling over or feeding on contaminated foliage. In light of our understanding of virus epidemiology, the individual nature of local outbreaks and lack of biological uniformity might well be the reasons for the failure of the virus to develop as an effective natural control. I would hope that in the excitement surrounding this forest insect epidemic, there are planned investigations underway of the mechanics of these local outbreaks to better understand the interactions between the virus and caterpillar population dynamics.

For the short term we have, I believe, three action step options.

Option 1. Do nothing. Let nature take its course. The folly of such a course of action must be apparent to all of us by now. Positive action to totally contain this pest is in keeping with our Nation's conservation ethic requiring the wise use of renewable natural resources. Acceptance of the conservation ethic requires us to reject out of hand option 1.

Option 2. I am distressed to learn that at this late date there is significant disagreement amongst the scientists gathered at this seminar as to the efficacy of DDT against tussock moth. It would seem such important information would be at hand so that forest managers could plan a course of action to control this pest. For the second action step EPA is urged to form a "blue ribbon" committee comprised of a majority of nonagency scientists to review data on efficacy of DDT against tussock moth. A call for all pertinent data published or unpublished should be made by EPA; then these data would be evaluated by the select committee. Such action would clear air as to who knows what.

Option 3. Initiate planning, based on EPA's action step above, to utilize the most effective insecticide available, including DDT if necessary, to control this epidemic. Reliance on the virus is chancy. The forest industry and public forestry agencies (State and Federal) have had experience in tooling up (including environmental impact assessments) for the successful control of forest insect pests using DDT—hemlock looper in 1963 and the tussock moth outbreak in 1965—so this should not be a deterrent to this course of action in 1974.

Recommendations

Now for four longer term recommendations that will, hopefully, help in eliminating the need of a seminar such as this in 1973-plus years.

Recommendation 1. Insure that the U.S. Forest Service is employing the most modern of forest insect survey techniques. New technology suggests that insect pheromones—sex attractants, to be specific—hold considerable promise as a means to assess population levels of lepidopterous insects. Also, remote-sensing technology—e.g., special photographic emulsions, infrared scanning, and perhaps other techniques—can be used effectively to track and assess the impact of forest insect outbreaks. It is essential that the Forest Service keep on the cutting edge of technology that has application in forest pest detection and control. The forest industry, by law and regulation, must look to the public forest land-managing agencies (at both State and Federal levels) for leadership in forest pest control.

Some of you will no doubt be surprised to learn there are no practicing industrial forest entomologists in this region. Since we rely solely on public agency experts concerning survey and detection, insect ecology, and control methods research, we expect a high level of technical competence to be maintained in these subject matter areas. Let us not find ourselves trying to put out a full-blown forest insect epidemic when a lesser effort might have controlled the attack if detected in its incipient stage.

Efficiency in survey and detection, together with full knowledge of forest insect population dynamics, does not equate to full effectiveness in controlling forest insect epidemics. We need biologically effective control agents, be they "viruses" or chemicals, to complete our control technology.

Recommendation 2. Construct a model describing the interactions between the "virus" and caterpillars at various population levels. Though this may seem like a theoretical exercise, it would no doubt provide some insights into how best to use biological controls. If my memory serves me correctly, I recall that one of the industrial forestry research representatives participating in a program review of the Pacific Northwest Forest and Range Research Station last year (1972) made such a recommendation. This recommendation is still viable, and such an endeavor should be initiated promptly. Although this approach would contribute little to the solving of the immediate problem to contain tussock moth, it is highly likely that a strategy will develop to make more effective use of artificial inocula of the virus in future outbreaks.

In the use of "virus," early instar caterpillars must continue to develop and move about to become infected. Thus, some level of defoliation must occur before control takes place. If a breakthrough increasing the effectiveness of the virus were to occur in 1974, it probably would be 1975 before a general collapse would take place. So we can look forward (in a negative sense) to another two seasons of defoliation. But we should not reject the proposed model-building effort for this reason. If the Pacific Northwest Station lacks in-house talent to do the total job of model building (and this will require highly specialized skills), then such talent should be acquired on a contract basis. It may be desirable from a research standpoint to reserve several of the smaller outbreak foci for experimental purposes. No stigma should be attached to such a request by the U.S. Forest Service.

Recommendation 3. We frequently hear discussed the virtues of an "integrated" approach to insect pest control. This approach calls for the blending of direct control (toxicants) and biological controls (the enhancement of natural controls); in the case of forest insects, silvicultural controls on insect populations. We have in the Pacific Northwest a history of tussock moth outbreaks in the mixed conifer type. It would seem appropriate to initiate research to investigate the potential of silviculturally insectproofing this forest type against tussock moth. Forest entomologists have a good understanding of the silvicultural factors controlling spruce budworm epidemics in eastern coniferous forest types. The proportion of balsam fir in a stand is the controlling factor—a high proportion of balsam fir results in increased hazard of a stand to attack by the spruce budworm. What silvicultural factor influences the occurrence of tussock moth? This ecological or silvicultural approach to controlling tussock moth is long range in scope with the practical payoff to such a research effort some years off. It would be a high order of forest management if we could learn to insectproof the mixed conifer type to tussock moth. It is our recommendation to this group that the planning for such a research effort be initiated.

Recommendations 1, 2, and 3 pertain primarily to the Forest Service.

Recommendation 4. Our fourth recommendation is directed to EPA and it is in keeping with EPA's philosophy of developing new how-to-do technology to protect environmental quality. EPA currently plays the role of an environmental policeman with regulations on the do's and don'ts concerning the use of pesticides. And, shortly, EPA will be involved to some degree with forest practice guidelines. Specifically, our fourth recommendation is this: EPA join the U.S. Forest Service and U.S. Bureau of Sport Fisheries and Wildlife to initiate a truly national effort to develop effective and environmentally safe pesticides for use on forest lands.

In the midsixties, the forest industry in the Pacific Northwest recognized the need to seek a replacement for DDT. The industry, working through the Northwest Forest Pest Action Council, was the catalyst bringing together experts from the Forest Service and U.S. Bureau of Sport Fisheries and Wildlife to discuss the possibility of developing—as they were referred to in those days—"safe to wildlife pesticides." To this meeting in Denver in 1964 the forest-pesticide-pioneering research group at Berkeley owes its origin. (The forest industry is not usually credited with such farsightedness by environmentalists.)

By allocating some of EPA's resources in this ongoing cooperative program with the chemical industry, an all-out effort to develop environmentally safe pesticides for forestry could be developed. EPA would have a positive role in forest-pest control.

Since the maintenance of environmental quality is EPA's charge, I feel (and this is a personal view) EPA should have some second thoughts regarding the degradation in environmental quality that is attendant to the current outbreak of tussock moth.

Appendixes

The appendixes include manuscripts submitted for the record and supplemental material in support of author presentations. Because the transcript of the afternoon session was not available at the time of publication, however, appendix material cited during that session is derived from manuscripts subsequently provided by the authors.

STATEMENT

Roland C. Clement

Vice President, National Audubon Society

Mr. Chairman, I have been the National Audubon Society's chief scientist since 1960; have devoted over 10 years to the analysis of DDT environment problems; have been a member of the National Gypsy Moth Advisory Council (USFS) since its inception; am a member of the Advisory Committee on Research/Northeast Region, USFS, a member of the California Condor Advisory Committee/USFS, Chairman of the Environmental Advisory Board to the Chief of the Corps of Engineers, and Chairman of the U.S. Section, International Council for Bird Preservation.

I recite these affiliations to show that I believe in working from the inside—cooperatively—instead of merely criticizing from the outside.

The U.S. Forest Service has always been a favorite Government agency of mine, but I recognize that the Forest Service is currently divided within itself on insect control. Through no fault of their own, they have not invested enough in continuing ecological assessment of insect pest populations. The result is internal vacillation and external buffeting. This confuses the public, because it becomes difficult to decide who the experts are.

My own expertise and experience is in the 25-year gypsy-moth/DDT controversy, much of it applicable to the tussock-moth problem. The science of DDT's undesirable effects in the environment is now clear to anyone willing to read the scientific literature and capable of understanding it, notwithstanding the frenetic claims of half a dozen individuals who belabor the issue to the contrary.

My comments are perhaps best organized under the headings of science, research needs, and what may be termed the sociology of the tussock moth problem.

Science

1. Two unpublished studies I have had access to, by Florida and California scientists, show *declining* body burdens of DDT in wild birds since about 1971. This reflects a gradual cleansing of the environment by natural processes as a result of various constraints placed on the use of DDT in recent years. It would be tragic to reverse this favorable trend by allowing additional uses of DDT until the environment has had the opportunity to cleanse itself more completely. At present the best barometers of environmental health relative to DDT poisoning are the reproductive health of birds at the ends of long food chains, such as the peregrine falcon. In Colorado last summer—for example—the last 13 pairs of these falcons

in that State produced only three young because most of them sat on rotten eggs. This is a result of thin eggshells that crack; and the thin eggshells are a result of DDT poisoning in the mother bird.

2. Our long experience with the use of DDT in attempts to control the gypsy moth in the East show that such use actually magnifies the amplitude of the moth's population ups and downs. In short, though we may succeed in knocking down occasional outbreaks, we make future outbreaks worse and thus get locked into continuing chemical-control programs. Practically speaking, there is no such thing as a one-shot use of DDT.

3. In the East, Federal and State governments have spent over $100 million in a vain attempt to control the gypsy moth. The National Advisory Committee on Gypsy Moth Control has now recognized that the gypsy moth is not truly a forest problem, that the damage it does is minor, and that, in any event, we do not know how to control it. The committee characterizes the gypsy moth problem as a "people problem," and recognizes that its solution, therefore, involves helping people cope with their individual problems. These problems are ecological, technical, economic, cultural, and psychological.

Research Needs

The Forest Service must be enabled, through congressional directive and support, to study forest pests ecologically. In the past the Congress has been shortsighted and impatient, and the Forest Service has had to do ad hoc research. This has not and will not provide results.

The forest is not a bunch of trees, but an extremely complex ecological community that must be understood before we can help correct occasional imbalances that seem to us undesirable. Forest insects which are pests are the exception to the rule, which means that nonpest insects are much in the majority. So far we do not even know enough about the few insects that are pests, let alone all the other insects that are members of the forest community. Our use of chemicals is likely to upset the forest community's ecology, and may actually create new pests and make existing pests more troublesome, instead of helping moderate our problems. This has happened several times in agricultural pesticides use.

The Forest Service must therefore—

1. Develop accurate outbreak prediction techniques. Present egg-mass counts are inadequate.
2. Develop uniform and/or comparable infestation-level and defoliation-level categories. None exist at present, and much unnecessary alarm is aroused by the reports of entomologists.
3. Define in uniform and/or comparable language such terms as "acceptable defoliation," "acceptable damage," and "acceptable control."

Sociology

The tussock-moth-control controversy, like the gypsy moth controversy, is typical of all the human problems which arise from a short-term-benefit outlook and from naive or exaggerated faith in the technological "fix."

This popular misunderstanding of the long-term public interest in ecological issues is not surprising. The public has been misled by sophisticated professionals who have been so enamored of their specialist expertise that they have overlooked the forest for the trees.

The benefit/cost analysis of the economist is typical of this overemphasis on specialized rationality. When such reasoning is applied to ecological problems it fails, because ecosystems are more complex than the methodology of economic science. What is overlooked is that advantages are more easily quantified than disadvantages; the short term is also more easily quantified than the long term. Identifiable benefits seem more real than uncertain future hazards.

The benefit/cost analysis, therefore, provides a false sense of objectivity, and the professional who is not also a philosopher may deceive more than he clarifies, because the public tends to overlook his scientific caveats.

DDT has obvious immediate effects. It kills insects. It therefore seems both effective and economic. But such a conclusion ignores or disregards the long-term damage DDT does to nonpest organisms. It imposes long-term costs that only patient and sophisticated analysis can keep track of. Since these costs are both more distant and more difficult to assess than the immediate benefits, it is difficult to include them in benefit/cost analyses. What is difficult is often neglected.

Where it is difficult or impossible to be scientifically objective, we must make ethical judgments. These are always less popular in our pseudoscientific culture. This problem is obvious to the irrelevant promise to do extensive monitoring of the requested spray program. How extensive, when 50 percent of the DDT applied is carried for miles on air currents instead of falling where it is applied? Will the entire regional ecosystem be monitored, since this is what is being affected? Who will pay for this long term monitoring program? Has its cost been computed and included in the program's benefit/cost analysis? How much dispersed long-term damage will be accepted for the presumed, focused, short-term benefits?

Given the professional and public confusion about benefits and costs, it is not surprising that political leaders reflect this confusion. If I may believe the press reports I have read, both the principal advocates of recent legislation to do an end run around DDT constraints imposed by the Congress and EPA—Congressman Mike McCormack of Washington and Congressman Steve Symms of Idaho—only 2 years ago made badly informed and intemperate public statements about the tussock moth problem. They have unfortunately compounded the confusion and polarized contending views on this issue.

Those who feel it necessary to opt for the short-term solution (use DDT), at whatever cost to others, resort to a common rationalization; their excuse is that "my little bit won't hurt." This is why we continue polluting. It also leads to juggling for advantage among user groups. For example, a spokesman for the American Plywood Association wrote to the National Audubon Society on October 8, 1973, that foresters like him "could not be a party to allowing farmers and housewives to continue promiscuous use of the chemical (DDT)"—but he considered an "emergency application" of DDT necessary for tussock moth control.

Mr. Chairman, these are all valid points—scientific, economic, and political—we trust you will weigh carefully in considering the request to resort once again to DDT.

We believe the costs of DDT use would greatly outweigh its benefits. But we have argued before the Congress that the decision is one EPA is competent to make, and should be allowed to make, without political interference. We will abide by your decision.

DDT EFFICACY

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Since 1945, there have been several insect-control projects in the Pacific Northwest where DDT was used, including the Douglas fir tussock moth. Some of these spray projects in Oregon and Washington are summarized in table 1 (Johannesen, 1970). The rate of application of the chemical varied from 0.5 to 1.5 pound per acre. For the Douglas fir tussock moth, the rate of application before 1964 was 1 pound of DDT per acre. After 1964, the dosage rate was reduced to 0.75 pound of DDT per acre.

DDT was first used against the Douglas fir tussock moth in 1947. A total of 413,469 acres was sprayed in northern Idaho, eastern Washington, and northeast Oregon (Evenden and Jost, 1948). One pound of DDT was applied per acre. Evenden and Jost report,

> the success of the spray program was far greater than had been anticipated. Instead of the 75 percent of the tussock moth population which it was hoped would succumb to the effects of DDT, postspray checks found close to 100 percent mortality everywhere in the treated area. Procedures to check the degree of mortality based upon the assumption that there would be some caterpillar survival were abandoned. There simply were no living caterpillars apparent in the treated area.

They also reported the ground was covered with thousands of small larvae which apparently dropped from the trees during the first 24 hours following treatment. The area was sprayed when the first larvae began to hatch from the overwintering eggs.

Evenden and Jost (1948) also reported the DDT spray had prevented continued defoliation. They believe the success of this project was due to the rapid coverage of the infested area by the spraying operations that permitted the spray to be directed against the early instars of the larvae.

During the period June 24 to July 2, 1947, some 14,000 acres on the Umatilla National Forest near Troy, Oregon, were sprayed. This was a part of the North Idaho project described above. Buckhorn (1947) reported the results of the spray were phenomenal. He stated "although considerable damage occurred to the timber before control was applied, wholesale destruction of the stand was prevented."

On the nearby Wallowa-Whitman National Forest, a new infestation of 1,500 acres was discovered near Promise, Oregon, in June 1947. About 320 acres of the most heavy defoliation was treated on July 15, 1947. Ground checks revealed the larvae ranged from third to

Table 1.—Previous DDT aerial spray projects for forest insect control in Oregon and Washington

Year	State	Insect species controlled	Total acreage sprayed ($\times 10^5$)	Application rate, pounds per acre
1945	Oregon	Western hemlock looper	2.3	1
1947	Oregon	Douglas fir tussock moth	14	1
1947	Washington	Douglas fir tussock moth	4.4	1
1948	Oregon	Spruce budworm	4	0.5-1
1949	Oregon	Spruce budworm	267	1
1950	Oregon	Spruce budworm	907	1
1950	Washington	Spruce budworm	25.9	1
1951	Oregon	Spruce budworm	791	1
1951	Washington	Spruce budworm	125	1
1952	Oregon	Spruce budworm	522	1
1952	Washington	Spruce budworm	135	1
1953	Oregon	Spruce budworm	369	1
1953	Oregon	Sawfly	1.2	1
1954	Oregon	Spruce budworm	67.7	1
1955	Oregon	Spruce budworm	621	1
1958	Oregon	Spruce budworm	818	1
1962	Washington	Spruce budworm	46.2	1
1962	Oregon	Western hemlock looper	32.5	.5
1963	Washington	Western hemlock looper	14	.75-1.5
1965	Oregon	Douglas fir tussock moth	66	.75

Source: From Johannesen, 1970.

fifth instars. Buckhorn (1947) reports this area was treated with a dosage of DDT similar to that applied on the Idaho and Troy areas. However, the results indicated very little larval mortality occurred. Buckhorn stated, "apparently the large larvae were more resistant to the small dosage of DDT which caused complete mortality of the smaller larvae on the other two projects."

The second Douglas fir tussock moth control project involving the use of DDT was in 1956 on the Stanislaus National Forest in Calaveras and Tuolumne Counties, California. A total of 9,560 acres was sprayed with 1 pound of DDT, similar to the Idaho project in 1947 (Stevens, 1957). The area was not sprayed until July 31, and this was after a significant amount of defoliation had already occurred. The larvae at the time of treatment were three-fourths grown (about fifth and sixth instars). Stevens (1957) observed "dying larvae began falling within a few hours after being sprayed. No living larvae could be found one day after spraying." He also reported no additional foliar damage occurred after treatment.

The effectiveness of DDT applied at a rate of 0.75 pound per acre for control of the tussock moth was first observed in 1964. It occurred at Knox Mountain in northern

California, where the U.S. Forest Service was testing DDT and malathion to control an outbreak of the white fir sawfly, *Neodiprion abietis* complex (Harris)—(Pierce, 1964). Entomologists reported a population of the Douglas fir tussock moth was present in the sawfly treatment area. During the evaluation of the sawfly treatment, the effects of DDT and malathion on the tussock moth population were determined. A total of 2,800 acres was treated with DDT and 320 acres with malathion. Both chemicals were applied at the time the tussock moth larvae were hatching.

During July and August 1964, 39 sample plots were established: 14 plots within the DDT-treated area, 7 plots in the malathion-treated area, and 18 plots outside the treated areas. At each plot egg masses were collected and separated as to the year of hatch, egg masses which hatched in 1963 or before (old masses), and those which just hatched in 1964 (new masses). The plots were resampled in October 1964 to collect and record egg masses which would hatch in 1965. The results of this survey showed the tussock moth infestation in the untreated area appeared to be rising sharply; this upward trend was also evident in the malathion-treated area, but in the DDT-sprayed area, no new 1965 egg masses were found. The results are presented in table 2.

In addition to the tussock moth outbreak that was rapidly developing in northern California in 1964, additional outbreaks were developing elsewhere in northern Idaho and central Oregon. The entomological survey indicated heavy defoliation would occur in 1965 in the three States; therefore, plans were made to control the moth. Originally it was planned to use 1 pound of DDT per acre. However, after being informed of the 1964 results obtained in northern California, the recommended dosage was reduced to 0.75 pound per acre.

Table 2.—Average egg masses per sample tree

DDT-treated area			Malathion-treated area			Unsprayed area		
Hatch 1963	Hatch 1964	Hatch 1965	Hatch 1963	Hatch 1964	Hatch 1965	Hatch 1963	Hatch 1964	Hatch 1965
0.06	0.69	0	0	0.44	2.9	0.006	0.07	7.19

Note.—Table based on the following data:

DDT-treated area:
1963 hatch, 9 egg masses found on 140 sample trees.
1964 hatch, 97 egg masses found on 140 sample trees.
1965 hatch, 0 egg mass found on 140 sample trees.

Malathion-treated area:
1963 hatch, 0 egg mass found on 70 sample trees.
1964 hatch, 31 egg masses found on 70 sample trees.
1965 hatch, 43 egg masses found on 15 sample trees.

Unsprayed area:
1963 hatch, 1 egg mass found on 180 sample trees.
1964 hatch, 269 egg masses found on 990 sample trees.
1965 hatch, 7,119 egg masses found on 990 sample trees.

In 1965, 69,945 tussock-moth-infested acres located on the Malheur National Forest, Ochoco National Forest, State of Oregon lands, and private properties were treated. DDT was used at the rate of 0.75 pound dissolved in 1 gallon of fuel oil per acre when 70 percent of the egg masses hatched. Prespray and postspray tussock moth larval counts at 73 scattered plots were compared to determine larval mortality. The results of these calculations indicated that the spray project was very successful (table 3).

For the Douglas fir tussock moth infestation in northern California, a total of 47,796 acres were treated in 1965 with 0.75 pound of DDT per acre (Anon., 1966b). The chemical was not applied until after 60 percent of the egg masses in the treatment area hatched. Tussock moth mortality counts on this project were made by establishing 10 mortality stations (8 treated and 2 untreated) and caging an egg mass swarming with first instar larvae in a nylon-mesh sleeve cage. Ten days after spraying, the branches containing the nylon cages were clipped and taken to the laboratory for examination. The very excellent results are summarized in table 4.

A third Douglas fir tussock moth control project in 1965 was carried out in the Potlatch area of Idaho. This tussock moth project covered 119,872 acres of State, private timber company, and Federal lands (Anon., 1965b). DDT was applied at the rate of 0.75 pound per acre by fixed-wing aircraft and helicopter when 70 percent of the larvae were in the second instar. Twenty-six insect mortality lines, each consisting of 5-10 plots, were established. Prespray and postspray mortality counts were made at each plot from a 15-inch branch collected from each of two trees. Prespray fixed-wing mortality lines had a total of 2,416 larvae, and the helicopter lines had a total of 1,372. Six days after spraying no live tussock larvae were found on any of the established plots.

DDT was registered in 1966 for Douglas fir tussock moth control by the Allied Chemical Corporation at the rate of 0.75 pound per acre, USDA Registration No. 218-3. The 1965 efficacy data collected from the Douglas fir tussock moth control projects in Idaho, Oregon, and California were used to register DDT at the prescribed rate of 0.75 pound per acre.

Studies by Wickman (1958 and 1963), Wert and Wickman (1968 and 1970), Wickman and Scharpf (1972), and Wickman, Mason, and Thompson (1973) have indicated that tree mortality on DDT-treated areas is essentially the same when compared to untreated areas.

The efficacy of DDT to control the Douglas fir tussock moth cannot be based on the number or volume of trees that ultimately died in treated and untreated areas of past epidemics. It is not a true reflection on the effectiveness of DDT against the tussock moth, because the areas used may not be comparable. Some of the major differences between untreated and treated areas are the density of the tussock moth population, the incidence of the virus disease present in the population, the variability of other natural control agents, the timing of the treatment as related to size of larvae and age of the outbreak, and the secondary effects other insects, primarily bark beetles, exert in defoliated stands.

One of the examples used for comparing tree mortality between an untreated area and a DDT-treatment area has been the 1937 Mammoth Lakes outbreak (untreated) and the 1956 outbreak on the Stanislaus National Forest that was treated with 1 pound of DDT per acre.

Tree mortality on the Mammoth Lake outbreak amounted to 29 percent of the sawtimber volume 5 years after outbreak. Twenty percent of volume was killed in the 5 years

Table 3.—Summary of the tussock moth larval mortality on the 1965 Burns Douglas fir tussock moth control project

Unit	Spray blocks	Mortality plots	Larval count		Percent mortality
			Prespray	Postspray[1]	
King Mountain	14	42	4,379	70	98
Antelope Mountain	9	15	1,854	77	96
Gold Hill	5	8	877	0	100
Vance Creek	1	2	200	0	100
Silver Springs	1	3	182	0	100
Project total	30	70	7,492	147	98

Source: Parkins and Dolph, 1967.

[1] Larval count 10 days after spraying.

Table 4.—Knox Mountain-Cedar Pass project tussock moth larval mortality

Block	10 days after treatment		Percent mortality
	Live larvae	Dead larvae	
Hermit Butte	0	372	100
Tom's Creek	0	538	100
Hilton Creek	0	535	100
Canyon Creek	0	378	100
Knox Mountain	0	228	100
Manzanita	6	227	97.4
Middle Ridge	4	388	99
Cedar Pass	3	340	99.1
Total, treated areas	13	3,006	99.6
Check area 1	271	221	44.9
Check area 2	184	153	45.4
Check area average	455	374	45.1

Source: Anonymous, 1966.

after the Stanislaus outbreak. (Bark beetles accounted for 75 percent of the tree killing.)

One of the reasons why tree mortality on the Stanislaus (treated) was similar to the Mammoth Lakes (untreated) losses could be related to the fact that the tussock moth on the Stanislaus area was allowed to damage trees for 2¾ moth generations (1954, 1955, 1956) before it was terminated with DDT. The larvae at the time of treatment (July 31 and August 1-2) were already three-fourths grown, hence they had sufficient time to consume enough of the foliage to cause additional tree mortality of top kill prior to treatment.

Another example used in an attempt to show ineffective DDT results has been Roney Flats (untreated) and Stowe Reservoir (treated) located in the 1965 outbreak in northern California. A year after treatment, tree mortality in the Roney Flats area amounted to 27 percent and 25 percent at Stowe Reservoir. In 1967, tree killing at Stowe Reservoir increased to 32 percent; there was no similar measure taken at Roney Flats.

Although tree mortality the first year after treatment was similar, the areas are not comparable due to population levels and incidence of virus. Therefore, it is a moot question as to how much additional damage DDT prevented after it was applied at Stowe Reservoir. The trees at Stowe Reservoir had already been severely damaged in 1964 and there was a significant difference in the population levels found in the two areas. Results of the 1964 fall egg-mass survey in the two areas are shown in table 5. The results indicate 21.5 times more egg masses were present in the Stowe Reservoir area than at Roney Flats.

Although virus disease was reported to be present in each study area, the amount is unknown. Because the virus data were vague and there was no assurance that the population would collapse before additional damage occurred, the decision was made to treat the Stowe Reservoir area with DDT. The outbreak at Roney Flats was not treated. It was set aside for additional virus research.

Research investigations by Wert and Wickman (1970) and Wickman et al. (1973) show the tussock moth larvae did a considerable amount of damage before virus suppressed the population on the untreated areas. At Roney Flats, the larvae removed all of the new foliage and some older foliage before the virus disease caused the population to collapse. Based on visual estimates on 107 trees in May (before feeding) and August (after feeding), defoliation increased on 51 percent of the sample trees. None of the trees showed foliage gains during the summer. In the Stowe Reservoir area, most of the new foliage was gone before the area was treated in late June. Defoliation had increased on 11 percent of the 105 sample trees. By August, after treatment, a total of 40 trees (38 percent) showed improvement with increased foliage growth. Wickman et al. (1973) suggest the DDT control program at Stowe Reservoir did save foliage.

Table 5.—Fall egg-mass survey results, 1964

Unit	Number sample trees	Total egg masses collected	New egg masses	Old egg masses	New-to-old ratio
Stowe	12	2,268	2,221	47	47.3:1
Roney	20	139	96	43	2.2:1

STATEMENT

Dr. Steve Herman
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I am here for several reasons. One is that I have acted as a scientific advisor for a number of groups, which I prefer to call conservation groups, for possibly the last year. Another is that my interest in forest entomology dates back to the late 1950's, when I worked with Dr. Allen Telford on the lodgepole pineneedleminer and the early 1960's when I worked with Dr. Dahlsten on the white fir sawfly and the Douglas fir tussock moth. My graduate work was done on pesticide wildlife relationship, for some idea why I am interested in the issue.

I would like to apologize for the fact that I am going to be somewhat repetitious, as well. I would hope, however, that my points of view would be slightly different, perhaps different enough in some cases that the repetition will not be complete.

Someone has remarked, with reference to the fact that precipitated this seminar today, that it has never been a tussock moth issue; it has always been a DDT issue. The accuracy of that statement is obvious, and it necessitates the conclusion that research needs cannot be considered appropriately until the present atmosphere has been cleared by recognizing, and perhaps accepting, national and agency policy.

At the national level, that policy is that DDT would be used only in the case of a national emergency. At the agency level, DDT was by and large phased out toward the end of the 1960's. The fact that DDT has been allowed to dominate the issue has had a number of pernicious oppressive results. It has stifled communication at the agency level, and has restricted agency/public-interest-group communication. It has obscured the reality of pest-population collapse in many areas, and I would like to add, at this point, that I was extremely pleased to hear Dave Graham this morning make the point rather emphatically that there has been a very significant collapse in the pest population over much of the area. That is one of the first clear statements of that reality that I have heard.

Now another thing I think needs to be mentioned with regard to the collapse and the damage is the fact that much of the tree mortality, which is the most significant aspect of the damage the pest does, was probably accomplished in 1972 or was the result of defoliation which took place in 1972; and 1972 is a year when no control was requested by an agency. So it is not a matter of, "we could have saved our forest." It has reduced the probability that decisions will be made on the basic and scientific evidence, and increased the probability that policy will be determined primarily by emotional and political needs.

But most importantly, in my view, the intrusion of DDT has had an adverse influence on research and researchers. I am convinced it has been responsible for the temporary suppression or distortion of data. Certainly it has resulted in the tardiness of data on several occasions. There is evidence that it has threatened the security of some workers of both persuasions. The free discussion and exchange of data have been discouraged, and the judgments of researchers sometimes have been ignored. Unless these stigmata are removed, and I have suggested a means of removal, we cannot hope to proceed with a research program in an atmosphere of academic freedom and scientific objectivity.

With regard to the research needs themselves, I think we should temper our priorities with the knowledge that the Douglas fir tussock moth is a native insect of transient and irregular importance. While the extent of defoliation in the declining 1973 infestation may have been historically important, there are certainly other insects which, in the long run, are actually or potentially more important.

I have attempted to arrange the list of research needs in such a way that it follows the normal pattern of events in infestation cycle.

Endemic Populations

Apparently there have been no extensive studies of the endemic population. I am not sure that a truly endemic population has been identified. We speculate that endemic populations are controlled by parasites and predators. We know that epidemic populations are frequently terminated by the virus disease. It seems probable that a population-dynamics approach at the beginning of the endemic level would be most productive. What triggers periodic release of these endemic populations? We tend to speculate that climate somehow influences release. But climate can only be a proximate factor. We need to know the ultimate factor or factors governing release.

On Detection of the Incipient Outbreak

There has been much talk about and support for research designed to identify and sympathize tussock moth pheromones, largely for the purpose of perfecting an early-warning system. While these efforts certainly should be encouraged, it should also be realized that pheromones, for all their current popularity, are not alone likely to solve the problem of detection. Research should also focus on approving other techniques of detection, including the beating plots and the education of onsite personnel. By that, I mean people who are in the field—the rangers, for example, who are in the field constantly.

A sampling system for predicting incipient outbreaks has been developed. Unfortunately, it was not widely applied in this infestation, when elements of the infestation were first detected in 1971. Nor apparently was it employed in comparable areas in 1972. Instead, it has been used essentially unchanged in the attempt to estimate damage in 1974. The sampling procedure was not designed for that purpose. Research should evaluate the system's utility in an epidemic situation before it is actually employed to determine projected control strategy.

Release Population

Ideally, controls should be directed at populations during the release phase of an outbreak, before the majority of damage has been done. Although it appears that most populations in the current outbreak are beyond that point, research with synthetic and microbial insecticides should focus on the release stage. Furthermore, this research should consider primarily the possibility of providing protection for the small private owner, who always suffers most in the effects of this pest. No artificial control, whether attempted with synthetic organic pesticides or microbials, will be without disruptive ecosystemic effect. Research should bear this in mind, especially with regard to naturally occurring parasites and predators. The efficacy of any new material must be carefully and properly documented in the field. This means that control plots and adequate sampling design must be employed.

It is a sad commentary that, after over 20 years of DDT use against tussock moths, we are left with no adequate data concerning the efficacy of the poison, under field conditions. In some cases this deficiency was the cause of oversight or poor planning; but in most and perhaps all cases it resulted from the catastrophic influence of the natural virus, which decimated populations on both control and experimental plots. By focusing our attentions, with regard to new materials on population in the release phase, this interference might be minimized. Investigations of the roles of natural enemies should be accelerated during the release phase. What population characteristics during this phase can give clues concerning the mechanism of release? What can we predict for the following year? Within the pest population itself, it will be important in the release year to examine parameters of fecundity dispersal and possible genetic factors that may express themselves. Ecology and economics of defoliation and tree mortality must be examined in depth.

Keying from the observation that Douglas fir and true firs coexisted with this pest aboriginally, we must consider the possibility that a symbiotic relationship prevailed prior to the advent of modern forest practice. That relationship, if revealed, might be turned to some advantage. The economics of tree mortality are especially important in mixed stands where salvage logging is used as a management tool.

Declining Population

In the third year, which is most commonly the year of collapse for the pest population, studies begun earlier should be continued, with special attention given to the epidemiology of the virus disease to include interactions with other natural enemies. A precise mechanism to the decline of the population, particularly at the periphery of the infestation, should be investigated. This would also be an ideal time to refine our understanding of the timing of exposure. Secondary invaders like bark beetles would come under special scrutiny at this time. The role of parasites and predators, which is characteristically most significant during this phase, should be given particular emphasis.

Viewing the research picture as a whole, two deficiencies are particularly obvious to me. Parasites and predators have been investigated only superficially. While we have partial information on the species involved in various infestations, we know virtually nothing about life history, including alternate hosts. The possibility of classic or near-classic biological controls seems as remote with this species as it does with any native forest insect, but variations on that theme (one of which was described this morning), some of which involve environmental manipulations of understory or the introduction of parasites absent in one area from another locality, remain possibilities. None of this work should be attempted until the life histories of the natural enemies are understood.

Second, survey and predictive techniques must be refined. The techniques currently in use are simply not adequate to the tasks, and will not support a proposed spray program. The old-to-new egg-mass-ratio system apparently dates from 1947 infestation. To my knowledge, its predictive power has never been tested quantitatively. It also suffers from some inherent biological bias. It seems probable that existing data might support it, but until the evaluation of the technique goes beyond the anecdotal phase, it cannot be considered useful.

The system that relates density of egg masses to pest density after hatching is the most sophisticated system, but it is my impression that it was designed for first instar larvae and incipient outbreaks, not egg masses in older infestations. Certainly an adaptation of it would be useful, but again I am aware of no test that has demonstrated sufficiency in this situation. As practiced by the agencies currently surveying egg masses, it is superficial in that it fails to accommodate, first, the irregular distribution of host trees and, second, the irregularity of the pest within the host-tree pattern on both a vertical and horizontal front.

The time-plot approach, also being misused this year, and apparently for the first time with tussock moth, seems inherently plagued with a large number of unmanageable variables. It may be useful for determining presence or absence, but in its present form it is not a quantitative technique.

These criticisms are offered constructively, and with full and personal knowledge of the logistic and economic barriers involved in mounting a comprehensive population serving.

I might insert at this point that, with my colleague Dr. Buge and 38 other persons in the program that he and I are teaching at Evergreen State now, I attempted to sample part of the Douglas fir tussock moth infestation in the area around La Grande. We were over there for a week, the week of October 8, and we now have some of those data analyzed and more coming in daily. We just started counting numbers of eggs per egg mass.

The fact remains, however, that this area should be given very high research priority. As we discuss research needs today, we should bear in mind that a large volume of good work has been completed and published. Other work is in progress or planned. We should urge that the work accomplished be recognized and respected. And we should thank the small number of researchers who have produced the work, often on minuscule budgets and with extreme efforts.

Finally, I would like to suggest that some potential research in the current situation is research that need not be repeated, or that we should consider a very low priority. Monitoring programs have often been used as partial justification for spray programs using DDT. There is an innuendo present in their planning, to the effect that the monitoring program will somehow prevent damage. This is, of course, not the case, especially with DDT. The programs are always hastily arranged and underfunded, as in the case of the Burns project in 1965, and the Willopa Bay project in 1963. This is not to say that such a program should have been discouraged during the heyday of DDT, but monitoring programs should not be bones thrown to conservationists.

And we would benefit very little from additional information regarding the effects of DDT and DDE on nontarget organisms. The literature on that subject is voluminous, and those effects are now known to be largely deleterious. The association of eggshell thinning in birds with *p,p'* DDE is one of the best known ecological phenomena. It has been shown so many times, in both wild and captive species, that at least one journal has complained about receiving "further verifications of phenomena already demonstrated."

We have considerable information about the Douglas fir tussock moth now. If we are to move forward with research, if this seminar is to bear fruit, we must all lock arms and agree to clear the air of the poisons that obscure objectivity and inhibit cooperation by imposing the constraints of politics and emotionalism. Thank you.

STATEMENT

William Hazeltine, Ph. D.
Butte County Mosquito Abatement District, California

My name is Bill Hazeltine. I would like to follow the theme that has been presented about having data, and I see Dr. Herman is still here, for which I am glad. I have to agree with his concept that there are things which have not come out. But what I wanted to specifically point out is some other ideas for the record, having to do with eggshell thinning.

The mallard duck and the sparrow hawk are the two prize species that are usually cited as proving that you can feed DDT to birds and get shell thinning. And sure enough, apparently they got it.

In the public hearing on DDT, Mr. Heath was a little reluctant, but he finally put in the residue levels in the birds (mallards), that he fed 40 ppm of DDE for about a year. He was able to get on the average of 13.2 percent shell thinning. The residue in those eggs after a year on feed gave an average of 146.6 ppm (wet weight). At a 5-percent lipid level, that calculates to be as high as any of the brown pelican eggs on Anacapa Island, which were 50 percent thin. In the case of the sparrow hawks, these birds were fed on 10-ppm DDE-spiked feed. At the end of the year, they had a net thinning of 7.6 percent; the residue was 23.4 ppm (wet weight), and this translates to something like 650 ppm lipid basis of 5 percent. It was also pointed out by Dr. Lucille Stickel that some of the confined sparrow hawks, before they even started feeding them DDE, were cracking and eating their own eggs. She attributed this to some kind of stress.

Individual aerie records for peregrine falcons in the Arctic are available, and these show that in one particular aerie the shells were 20 percent thin in 1954, and again in 1962 when the birds were apparently reproducing successfully, until the collapse in 1969 when the shells were 20 percent thin.

There are some data on prairie falcons, and I think they are really interesting. They are in a master's thesis by a fellow in Montana, available for $10.40 from the library there, and they show that the shells are now about 25 percent thin, average, based upon the comparison with pre-DDT days. They also show the individual egg data that happen to be in there, and show that if there is a correlation, the line is vertical. What this means is that with residues essentially noncorrelated—well, they are correlated with the shell thickness—but a change of only 1 to 2 ppm gave average shell thickness of about 25 percent. What this says to me very clearly is that the shells are thin with just the memory of DDE—it is not there and the shells are still thin. I would think that, to a prudent person, people would start to say "wait a minute, let's look and see what else is going on." If the DDE is not there, it seems to me that the cause-and-effect hypothesis is dead.

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Another interesting paper that Dr. Herman cited in his EIS comments is on prairie falcons in the State of Washington. This starts out with something about the effect of pesticides on the birds, but also in it is a calculated 17-percent shell thinning based upon the other records of shells normal pre-1940 or pre-DDT. It also shows that with the take of about 35 young for falconry, the birds that were surveyed were still producing an *excess* number of young to keep that population at a stable level. Here we were supposed to have problems with the birds, and yet the shells were thin and still they were producing an excess to take care of the population.

One other brief comment, if you will.

In the EIS there were data for sharp-shinned and Cooper's hawks. The residues for those eggs were in, but the shell thickness data were not. If you go to the Oregon State progress report from the Experiment Station, you find out, in the case of the Cooper's hawk, that there was a 14-percent difference in shell thinning. However, the eggs that had 14-ppm lipid-base DDE were the thinnest eggs. The eggs that had 65 ppm were the thickest. This is the *opposite* of cause and effect. The low-residue egg was the thin one, the high-residue egg was the thick one.

And so you put that together and I come back to the comment, wait until the data are in. I think we have had a lot of stampeding—if that's the right word—on the eggshell business in birds, and I would hope that people would keep an open mind and look at it. Thank you.

DOUGLAS FIR TUSSOCK MOTH DAMAGE ON TRIBAL FORESTLAND: COLVILLE INDIAN RESERVATION

Eddie Palmenteer
Chairman, Colville Indian Reservation

During the summer of 1972, it was noted that the Douglas fir tussock moth was defoliating and killing trees on approximately 1,800 acres of sawtimber on tribally owned forestland on the Colville Indian Reservation. The problem was discussed with forest entomologists, and the feeling was that the insect would be brought under control through natural causes. However, by the summer of 1973, the insect had spread to epidemic proportions on some 70,000 acres, and was causing visible damage on an additional 80,000 acres.

Preliminary estimates indicate approximately 50 million board feet of merchantable timber, with a stumpage value of better than $4 million, have been killed outright. We also estimate that the loss of growing stock will reduce stumpage income to the tribes by $500,000 each year for many years to come. This is a severe blow to the local economy and, if further spread of the infestation is allowed to occur, the effect upon the Indian people will be disastrous.

Potential Economic Loss to Tribes

If the Douglas fir tussock moth is not controlled on the Colville Indian Reservation, the economic loss to the Indian people will be felt drastically for many years to come by reducing their total income as much as 35 percent. Douglas fir is second only to ponderosa pine in importance as a sawtimber tree on the reservation, and it occurs in pure stands or mixed in with other species on approximately half of the 763,000 acres that make up the tribally owned forest property.

For the past 2 years, the annual average income to the tribes from sawtimber sales was $7.2 million, and Douglas fir accounted for 35 percent of this amount, or $2.5 million. At the present time, Douglas fir sawtimber is selling for a high of $128 per thousand board feet on the stump. At this rate, the potential loss to the tribes each year could amount to $6 million! It takes approximately 120 years to grow a Douglas fir tree to merchantable size on the Colville Indian Reservation. If the Douglas fir tussock moth is allowed to reach epidemic stage next year, it could conceivably wipe out all the Douglas fir growing stock and affect the tribal income for the next 120 years.

The Colville Tribal Council has passed two resolutions during 1973 regarding the Douglas fir tussock moth. The more recent of these (1973-791) authorizes and requests the Secretary of the Interior to allow the use of the insecticide DDT for control of the insect to prevent further depredation.

Exhibits

Exhibit 1

COLVILLE INDIAN RESERVATION

[Tribal forestland]

Area of reservation	1,354,289 acres
Area of tribal commercial forestland	761,380 acres
Total area of Douglas fir tussock moth infestation	150,000 acres
Heavy damage	40,000 acres
Medium damage	30,000 acres
Low damage	80,000 acres
Present volume of moth-killed Douglas fir sawtimber	50 million board feet
Present estimated value of dead Douglas fir sawtimber	$4.2 million
Proportion of Douglas fir in sawtimber stand	35 percent
Annual allowable cut	120 million board feet
Present value of annual cut (stumpage)	$10 million, estimated
Annual loss of income (potential)	$3.5 million, estimated
Time required to grow new crop of Douglas fir	120 years

Exhibit 2

1. **Area and value:**

   a. 60,000 acres, gross
   40,000 acres, net

   b. 1,500 board feet per acre, average

   Total, 90,000,000 board feet

   Approximately 30,000 acres are accessible with merchantable volume which equals 45,000,000 board feet at $70,000 =

   c. $3,150,000

   d. Immature and inaccessible area, 10,000 acres, $1,000,000

   Total value, $4,150,000

2. **Plans:**

   a. One sale presently under contract.

   b. Another up for sale in October 1973.

   c. Three more to be advertised this winter—specific areas and volumes presently being obtained.

   d. Pole-logging operations by the tribe will follow regular logging.

   e. Slash from both operations will be piled and burned.

   f. Large extensive clearcut areas would have to be reforested; but for the most part ours is a mixed stand and natural regeneration will probably be adequate.

3. **Forecast:**

   La Grande outbreak tripled in third year. Therefore ours could go to 200,000 acres, if: (a) no chemical control is used, and (b) the virus does not build up.

Exhibit 3

RESOLUTION 1973-310

WHEREAS, there is at present an abnormally high population of the Douglas-fir Tussock Moth on the Colville Indian Reservation which has reached epidemic proportions; and

WHEREAS, the Douglas-fir Tussock Moth has damaged Indian timber with a known value of $77,770.00,* and an unknown quantity of additional timber; and

WHEREAS, on the basis of studies undertaken by the United States Forest Service and the Bureau of Indian Affairs, an increase in the population of the Douglas-fir Tussock Moth and related damage will most likely occur in 1973.

BE IT, THEREFORE, RESOLVED, that we, the Colville Business Council, meeting in SPECIAL Session at the Colville Indian Agency, Nespelem, Wn., acting for and in behalf of the Confederated Tribes of the Colville Reservation this 11th day of APRIL, 1973, do hereby authorize and request that the Bureau of Indian Affairs take such action as is necessary to combat the Douglas-fir Tussock Moth and thereby prevent further damage to the natural and economic resources of the Colville Confederated Tribes.

BE IT FURTHER RESOLVED, that if other methods are not available, the use of ZECTRAN, DDT or other chemical agents determined to be safe and to cause a minimal amount of environmental damage may be used in a reasonable and controlled manner.

*Whitmore Salvage Sale	$38,334.20	Appraised Value
Hungry Moth Salvage Sale	$39,439.75	Appraised Value
TOTAL	$77,773.95	

The foregoing was duly enacted by the Colville Business Council by a vote of 9 FOR; 0 AGAINST, under authority contained in Article V, Section 1(a) of the Constitution of the Confederated Tribes of the Colville Reservation, ratified by the Colville Indians on February 26, 1938, and approved by the Commissioner of Indian Affairs on April 19, 1938.

ATTEST:

(signed) Joseph A. Kohler, Acting Chairman
Colville Business Council

Exhibit 4

RESOLUTION

1973-791

WHEREAS, on April 11, 1973, the Colville Business Council passed a resolution calling for aid in combating an epidemic of Douglas-Fir Tussock Moth on the Colville Reservation; and

WHEREAS, this epidemic has increased tenfold so that there are now 60,000 to 70,000 acres of damage with 50,000,000 board feet of Douglas-Fir killed. The average stumpage value on Reservation logging units is about $95.00 per M feet, B.M., for a total value of approximately $4,750,000.00; and

WHEREAS, unless this epidemic is stopped by June, 1974, there will be 200,000 acres devastated with approximately 200,000,000 board feet of Douglas-Fir killed for a total value of $19,000,000.00; and

WHEREAS, the only proven control of the Douglas-Fir Tussock Moth is by the use of DDT.

BE IT, THEREFORE, RESOLVED, that we, the official members of the Colville Business Council, assembled in Official meeting at the Colville Indian Agency, Nespelem, Washington, acting for and in behalf of the Colville Confederated Tribes this 29th day of AUGUST, 1973, do hereby authorize and request the Secretary of the Interior to require the release for DDT for use to combat this emergency on the Colville Indian Reservation for the control of the Douglas-Fir Tussock Moth.

Done and dated this 29th day of AUGUST, 1973, at the Colville Indian Agency, Nespelem, Washington, by a unanimous vote of 11 FOR; 0 AGAINST, which will be officially confirmed during the next Colville Business Council meeting.

ATTEST:

(signed) Eddie Palmenteer, Jr., Chairman
Colville Business Council